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THESIS

WORKLOAD MANAGEMENT AND PLANNING FOR A MAJOR RANGE AND TEST FACILITY BASE ACTIVITY OF THE NAVAL AIR SYSTEMS COMMAND

by

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June 1980

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I. INTRODUCTION

A. STATEMENT OF THE PROBLEM

Throughout the 1970s, increased emphasis was placed on test and evaluation (T&E) in the weapon system acquisition process. In order to ensure that all Major Range and Test Facility Base (MRTFB) activities are adequately provided with the required resources to satisfactorily fulfill their enhanced mission in the development test and evaluation of material and weapon systems for the Navy, it has become necessary that extensive planning and programming be conducted at the activity level. Accurate planning and programming are necessary, not only to justify required resources, but to defend current funding and manpower levels in the face of increased budgetary constraints within the Department of Defense.

A requisite for effective resource planning for a MRTFB activity is the ability to quantitatively measure and forecast test and evaluation workload requirements. This involves deriving a precise, unambiguous definition of workload which is applicable to all MRTFB activities, devising a method of accurately measuring workload, and formulating a predictive model for resource planning based on the workload requirements.

B. BACKGROUND

With the establishment of the Defense Systems Acquisition Review Council (DSARC) in the early 1970s and issuance of DOD Directives 5000.1 and 5000.2, which explicitly delineate the procedures to be employed during the acquisition of major defense systems, increased stress was placed on the role of test and evaluation. This was further intensified in 1976 with the issuance of Office of Management and Budget Circular A-109 [Ref. 1] and subsequent revisions of DOD Directives 5000.1 and 5000.2 [Refs. 2 and 3]. These documents are explicit in specifying that test and evaluation shall commence as early as possible and that decisions made at each acquisition milestone shall consider test and evaluation results.

Early and continuous involvement of test and evaluation in the systems acquisition process is more explicitly delineated in DOD Directive 5000.3 [Ref. 4]. This directive specifies that, at each acquisition milestone review, the Defense Coordinating Paper (DCP) address test and evaluation results, and that the DSARC is supported by a test and evaluation assessment. In order to ensure that test and evaluation planning occurs early in the acquisition process, a test and evaluation master plan (TEMP), which identifies and integrates objectives, responsibilities, resources and schedules for all test and evaluation, is required to be submitted, and to be approved by the Office of the Secretary of Defense prior to the Full Scale Development decision.

It is noted that the requirements of DOD Directive 5000.3 apply to major defense systems acquisition programs defined as programs involving an anticipated cost of $75 million for RDT&E or $300 million for production [Ref. 2]; however, those programs not designated as major programs are required to be guided by the same principles. Consequently, the Chief of Naval Operations (CNO) classified Navy acquisition programs into four categories (ACAT) [Ref. 5] in accordance with dollar value thresholds. ACAT I corresponds to the major acquisition programs defined above, and ACATs II through IV are governed by lesser dollar value thresholds. In Ref. 6, CNO further specifies that development test and evaluation, with the rigor delineated in DOD Directive 5000.3, is required for all four ACATs.

In consonance with the increased importance of development test and evaluation in the defense system acquisition process, the need for improved management of test and evaluation activities was recognized by OSD. Consequently, in 1974, DOD Directive 3200.11 [Ref. 7] promulgated policies for the use, management, and operation of all DOD test and evaluation facilities, which were consolidated to form the DOD Major Range and Test Facility Base (MRTFB). The activities comprising the DOD MRTFB consisted of 26 test and evaluation activities of the Army, Navy and Air Force. The Navy elements of the MRTFB are listed in Table I. In order to consolidate management of Navy ranges, test activities, and

TABLE I

NAVY ELEMENTS OF THE
MAJOR RANGE AND TEST FACILITY BASE

1.	Pacific Missile Test Center
2.	Atlantic Undersea Test and Evaluation Center
3.	Naval Air Test Center
4.	Naval Air Propulsion Center
5.	Naval Weapons Center (T&E Portion only)
6.	Atlantic Fleet Weapons Training Facility

target test resources, Commander, Naval Material Command, in 1976, assigned management responsibilities for the Navy elements of the MRTFB to Commander, Naval Air Systems Command (NAVAIR) [Ref. 8]. This responsibility was delegated to the Assistant Commander for Test and Evaluation (AIR-06). Among other requirements, Ref. 8 specified that the MRTFB activities "Provide workload information planning, programming and budgeting inputs to NAVAIR (AIR-06)." It further specified that AIR-06 "Balance workload and resources and prepare and defend the consolidated and coordinated MRTFB and target program support plans at the OPNAV and OSD levels as part of the PPBS process."

In recognition of the importance of workload management and planning, the Chief of Naval Material, in 1978, promulgated policy, responsibilities, and procedures for workload management at the Navy MRTFB activities [Ref. 9]. As cognizant manager of the Navy MRTFB, AIR-06 has the responsibility for introducing and controlling workload to the Navy MRTFB activities. Furthermore, the activities are directed to

to perform workload management and planning to ensure adequate resources, including funds, personnel, equipment, and facilities to meet user requirements. As an essential ingredient to the management of the Navy MRTFB workload, written estimates of planned workload are to be provided to the activities by the workload sponsors.

To exercise its responsibilities in consolidating workload information and workload planning for the Navy MRTFB, AIR-06, in 1976, established a requirement for an annual Test and Evaluation Field Activity Plan (FAP). The FAP is the primary planning document for the MRTFB activities. It promulgates planning policies and details for the time period of five years beyond the budget year, with the prior fiscal year used as the baseline (e.g., the 1980 FAP includes data for FY 1979 through FY 1986). The FAP contains a complete compilation of all test and evaluation projects planned during the planning period and includes requirements for funds, manpower, military construction, major repairs and minor construction, improvement and modernization projects, tenant support, and facility utilization. The FAP is compatible with the Five Year Defense Program (FYDP), and provides planning data and resource requirements for inclusion in the FYDP via the Program Objective Memorandum (POM). The FAP is updated each Spring to allow NAVAIR sufficient time to conduct a thorough analysis of the contents and provide data to OPNAV for preparation of the Preview CNO Program Analysis Memorandum (CPAM) (The first phase of the POM

process) which is presented in September. The annual MRTFB budget, which is submitted to NAVAIR by each MRTFB activity, is based on the planning data presented in the FAP.

Typically, continual correspondence between AIR-06 and the MRTFB activities takes place during the late Summer/ early Autumn time period to clarify, amplify, and justify information presented in the FAP and MRTFB budget. These requirements are normally in response to questions raised as the programming and budgeting cycles progress up the hierarchy. In November, during the development of the CPAM, a formal request is normally forwarded by AIR-06 to the Navy MRTFB activities to provide POM issues to be included in the CPAM. Correspondence pertaining to the POM issues normally continues up until the presentation of the Summary CPAM in February.

C. WORKLOAD ASSIGNMENT AND FUNDING POLICIES

The MRTFB activities of the Naval Air Systems Command are Naval Industrial Fund (NIF) activities. Operations of NIF activities are financed through the use of a self-sustained, revolving, working capital fund (corpus). This fund is reimbursed by other commands or activities for whom work is performed or services are rendered. Thus a seller-buyer relationship exists between the MRTFB activities and the "customers." All funds are received by MRTFB activities in the form of NIF reimbursables.

Navy MRTFB activities operate under the Uniform Funding Policy promulgated by Ref. 7. Under this policy, the customers are charged only for direct costs; overhead charges are not applied.[1] This is in contrast with other NIF activities at which reimbursable costs charged to the customers include an apportioned amount to cover overhead costs. In order to cover overhead costs at activities governed by the Uniform Funding Policy, a special fund, designated as the Institutional Fund, is provided. This fund, which covers such costs as indirect labor, facility maintenance and operation, improvement and modernization, major repairs, etc., is provided under the RDT&EN appropriation (program element 65864N), and is assigned by Work Request (NAVCOMPT Form 140) from the Naval Air Systems Command.

Funds provided in direct support of work performed for customers, designated as User/Direct funds, are normally provided by Work Request; however, some funds are provided by Project Order (NAVCOMPT Form 2053). User/Direct funds originate from several different appropriations as dictated by the nature of the work to be performed. The following

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[1] Exceptions are: Work funded by non-federal government agencies, commercial users or foreign governments. Ref. 7 specifies that these users will reimburse the ranges and test facilities for full costs. This policy is being modified by a revision to Ref. 7 (Draft dated 9 August 1979), in which only DOD component users will be covered by the Uniform Funding Policy. Specific guidelines for application of overhead costs to non-DOD component users will be covered in the revision to Ref. 7.

breakdown of funds received at the Naval Air Test Center is presented as an illustration of the funding process at a typical Navy MRTFB activity.

The major portion (approximately 80%) of User/Direct funds received at the Naval Air Test Center is in support of development test and evaluation projects sponsored by the Naval Air Systems Command. Most of these User/Direct funds come from the RDT&EN appropriation for test and evaluation to be performed on systems which are still under development, and from APN appropriation for test and evaluation to be performed on systems which are in production. A small portion comes from the O&MN appropriation for work in support of fleet units and operating forces, and from other procurement appropriations as appropriate.

Most of the remaining 20% of the User/Direct funds received at the Naval Air Test Center are in support of work performed for tenant activities, other field activities, and various commands within the Department of Navy. User/Direct funds in this category are normally O&MN or NIF (when received from other NIF activities); however, some of these funds may come from RDT&EN and procurement appropriations as applicable. Less than 2% of the funds received at the Naval Air Test Center is in support of work performed for other DOD agencies and non-DOD activities.

The process to be followed in the assignment of Navy MRTFB workload is delineated in Ref. 9 which states that "Navy test and evaluation workload assignments must be

directed to the Navy activity having the mission responsibility and capability to support such assignments." Workload is assigned by the Naval Air Systems Command in the form of AIRTASK/Work Unit assignments as delineated in Ref. 10. The AIRTASK is the principal document promulgated by the Naval Air Systems Command for assigning work to field activities. The AIRTASK formalizes agreements between the Naval Air Systems Command and the field activity on the technical work to be performed and funded in a given fiscal year. More detailed assignments are made and funded for performance of specific tasks within the scope of a previously assigned AIRTASK by means of Work Unit assignments. It is noted that the AIRTASK/Work Unit assignment does not authorize obligation of funds. Funds are provided by separate funding documents, normally Work Requests.

D. OBJECTIVE

The objective of this study is to conduct an analysis of methods and procedures for quantifying, measuring, and predicting workload requirements to facilitate planning at a Major Range and Test Facility Base (MRTFB) activity of the Naval Air Systems Command. Improved methods of workload analysis and reporting will be developed, as applicable, to enhance MRTFB workload management and planning at the activity and at the Naval Air Systems Command. Although the Naval Air Test Center will be used as the model MRTFB activity for the analysis, the concepts will be sufficiently general to be applicable to all MRTFB activities.

II. DEFINITION OF WORKLOAD

In order to achieve the objective of quantifying, measuring, and predicting workload, it is first necessary to define that which is to be quantified, measured, and predicted. Several definitions of workload exist; however, attempts to apply them to RDT&E activities such as those of the MRTFB have often led to frustration because of the unstructured nature of the work performed at these activities. Consequently, there is currently no standard definition of workload which is uniformly accepted among MRTFB activities.

A typical industrial engineering definition of workload is given by Nadler as:

> The time an operation or element of operation performed with a given method under given job conditions, should take; when worked on by an operator with the necessary skill and given sufficient training to perform the operation properly, working at the performance level, maintainable throughout the day, week, etc. specified as equivalent to the performance necessary to earn base pay; and when all the operator's required activity and needs are provided for. [Ref. 11]

This definition of workload is primarily applicable to a relatively structured working environment, and would be difficult to apply to the relatively unstructured working environment which exists at RDT&E activities such as those of the MRTFB. As Cooper, Neihaus and Nitterhouse point out:

> The more routinized, constrained, and/or well defined a task is, the easier it is to determine the relative efficiency and effectiveness of various alternatives

for its accomplishment. However, research and development is by definition not routine, constrained or well defined. [Ref. 12]

Cooper, Niehaus and Nitterhouse [Ref. 12] define "Projected workload" in terms of the task to be accomplished or the product to be developed (in other words, assigned projects). In order for this definition to be meaningful, conversion to a more definitive form would be required to facilitate quantification.

Reference 13 describes a workload planning system developed at the Naval Ship Weapons System Engineering Station in which the workload plan is based on funding data from the President's Budget. Defining workload in terms of budgeted funds is not considered valid since the funds may be used for purposes other than supporting workload (e.g., facilities, materials, general and administrative overhead). Furthermore, by using this definition, difficulties are introduced when an analysis is conducted to determine workforce requirements based on projected workload (as will be discussed in later sections).

A method for uniform measurement of capability, capacity, and workload for the MRTFB was developed at the Naval Weapons Center in 1977 in which workload is defined as hours of utilization of test facilities and ranges [Ref. 14]. This definition is apparently based on the tacit assumption that the total workload at a test and evaluation activity is related to the operation time of some test facility or range. In actuality, operation time of test facilities and ranges

does not necessarily reflect the test and evaluation effort expended. Furthermore, effort expended in operation of test facilities and ranges represents a small portion of the total workload during a test and evaluation project; the major portion being performed in engineering analysis. There is no direct correlation of effort spent in engineering analysis and utilization of facilities and ranges. Because of lack of adequate justification of a more acceptable definition, the definition of workload proposed in Ref. 14 has been adopted by the Naval Air Systems Command, and workload is currently being reported in this manner by Navy MRTFB activities.

In order for a definition of workload for a MRTFB activity to be meaningful, relevant, and consistent, it must be related to the effort required to accomplish the tasks associated with assigned projects. This effort is best expressed in terms of individual effort applied over a period of time; i.e., direct manhours (manyears in the aggregate). Thus workload for a MRTFB activity is defined as the direct manyears of effort required to complete assigned projects. This definition can be shown to be the most logical from several viewpoints. First of all, it is directly analogous to the basic definition of work given in the science of mechanics: Force applied over a distance. The analogy becomes apparent when it is considered that the applied effort of the workforce is analogous to the applied force and the time over which the effort is applied is analogous

to the distance over which the force is applied. In mechanics, if a force of one pound is applied over a distance of one foot, one foot-pound of work is accomplished. In the workforce, for example, a typist working for one minute accomplishes approximately seven foot-pounds of work; a machinist working for one minute accomplishes approximately ten foot-pounds of work.[2] For the purpose of measuring workload in an organization, it is more appropriate to express it in terms of manhours (or manyears) rather than converting it to physical units. Workload expressed as manhours (manyears) is relatively easy to estimate and can be readily converted to resource requirements (as will be shown). Furthermore, since accounting data are usually available in terms of manhours (for pay and labor distribution reporting), actual output can be measured for comparison with planned workload.

It is noted that the uniform funding policy facilitates measurement of workload, as defined above, since only those manyears of effort devoted to projects funded by User/Direct funds would determine the workload of the activity. To distinguish workload defined in this manner from indirect labor funded by the Institutional fund, the term, "Direct workload" or "workload in direct manyears" will be used in the analyses presented in subsequent sections.

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[2] Chase and Aquilano [Ref. 15] express energy requirements for various activities in terms of calories. For the purpose of the analogy, the data for the above examples were converted to foot-pounds of work using standard conversion factors.

Other definitions of workload, as described earlier in this section, may have limited usefulness under certain circumstances. The industrial engineering definition would be appropriate in a production environment. The number of assigned projects may provide an indication of workload, but would have to be converted to manyears to be meaningful. Funding is a resource required to finance the workload, and therefore, the magnitude of required funds would give an indication of workload (but not a direct measure). The number of hours of operation of facilities may be proportional to total workload if operation of the facilities represents a major aspect of the work performed at the activity, but it does not measure workload per se.

III. MEASUREMENT OF WORKLOAD

A. GENERAL

As noted earlier, since work in an RDT&E organization is not routine, constrained or well-defined, the workload measuring techniques of the industrial engineer are not applicable for MRTFB activities. However, as noted by Cooper, Niehaus and Nitterhouse [Ref. 12]:

> This is not to say that no one can have any idea of how many manyears of a specified skill level and occupation will be required to research area X or develop item Y. Scientists and engineers with knowledge of the technological state of the art, and with experience in performing similar extensions of applications thereof, can often provide reasonable estimates. This estimate usually is more accurate if it is done close to the level of direct supervisor or the personnel who will actually do the work, instead of several levels up the management ladder.

This philosophy is employed at the Naval Air Test Center for measuring workload for planning purposes. Since the measuring techniques utilized at the Naval Air Test Center, described in the following paragraphs, are applicable for all MRTFB activities, they are recommended for general use.

Workload requirements for assigned projects are determined by project personnel shortly after project assignment. These requirements are published in a project plan (referred to as a Test Plan) along with such pertinent information as the scope of the work to be performed, expected time-span, methods to be employed, techniques to be utilized, resource requirements, technical disciplines involved, safety precautions to be employed, and funding requirements. To

facilitate accurate estimation of workload, the work to be performed is broken down into specific tasks and cost centers at which the tasks are to be performed. Accounting data from previously assigned similar projects and the project personnel's experience and knowledge of the tasks to be performed provide bases for the workload estimate in terms of direct manyears of effort.

Estimation of projected workload requirements normally involves an extrapolation of current workload plus a forecast of anticipated projects to be assigned. The extrapolation process involves estimation of the length of duration of currently assigned work, additional work expected to be generated by results of current studies, and follow-on projects normally expected as a result of specific types of currently assigned work. The forecast of anticipated projects is facilitated by continuous communications between project personnel and project sponsors. It is noted that Ref. 9 requires that Systems Command workload sponsors provide, annually, written five-year planning estimates of anticipated workload to the Navy MRTFB activities. Reference 9 further requires that the Navy MRTFB activities request similar workload planning guidance from non-Systems Command workload sponsors. Additional information to assist in forecasting future workload requirements at MRTFB activities may be obtained from publications such as the Five Year Defense Plan (FYDP) and the Naval Aviation Plan.

The procedures delineated above describe the methods utilized at the cost center level for measuring workload for individual projects and tasks. It is apparent that, for overall activity workload management and planning, a formal process must be devised for consolidating and documenting all workload data at the activity. In recognition of this requirement, the author initiated the design of a Workload Plan Management System. With the assistance of the Computer Services Directorate of the Naval Air Test Center, an automated system was devised by which workload data may be entered and processed to produce aggregated workload requirements suitable for preparation of budgets, preparation of planning reports, general analysis and management of resources. This system has been adopted, and is currently being utilized by the Naval Air Test Center.

B. WORKLOAD PLAN MANAGEMENT SYSTEM

1. General Description

Workload data are provided by project personnel, and entered into the computer, for each current and expected project to cover the period from the previous year to five years beyond the budget year. Data for each project are provided on the Workload Planning Data input document shown in figure 1. Four blocks of data are provided as follows:

1. Workload
2. Direct Workload Requirements by Function and Fiscal Year
3. Aircraft and Flight Hour Requirements
4. Funding Requirements.

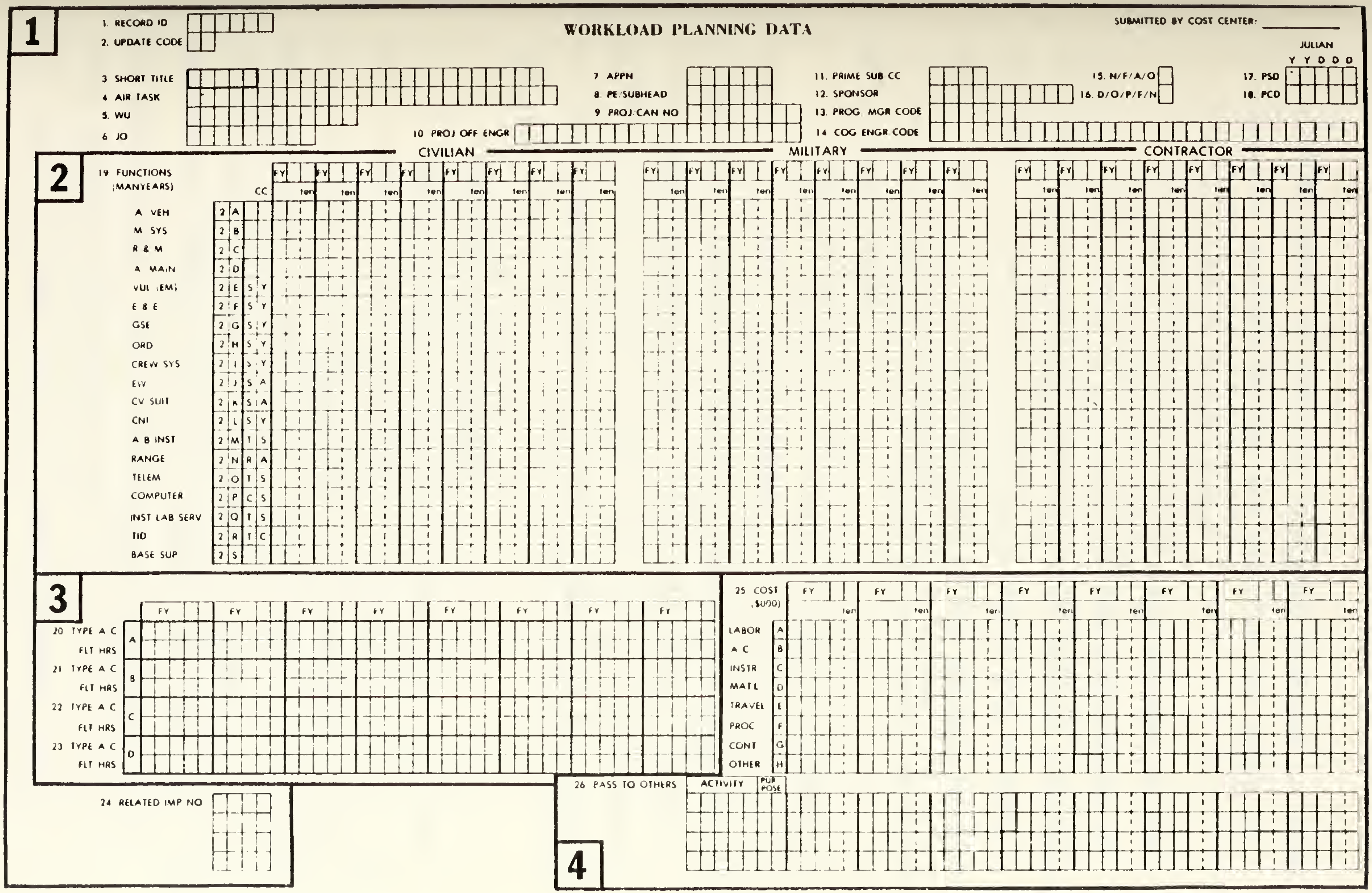

FIGURE 1
WORKLOAD PLANNING DATA INPUT DOCUMENT

It is noted that, in addition to direct workload in terms of manyears, specific blocks are provided for entry of significant resource requirements.

The workload data are completely updated in the Spring of each year to coincide with the preparation of the Field Activity Plan, and to provide updated information for budget preparation. Additional inputs may be made during the year, at the discretion of the project personnel, to provide inputs for new projects or to correct erroneous data in the system.

Outputs from the system are in various formats to satisfy a variety of requirements. Pre-programmed standard formats are provided to satisfy fiduciary requirements such as the Field Activity Plan. Highly structured, detailed information is provided to the operating levels. Generalized and unstructured information is provided for managerial analysis.

2. <u>Workload Identification</u>

Block 1 of the Workload Planning Data input document (figure 1) provides project identification data. The first two items are instructions to the computer to identify the record and to identify the type of input (i.e., initial, correction, deletion, or completion). The next four items identify the project by title, AIRTASK, Work Unit, and local job order number. This is followed by three data fields which identify the source of funds under which the project is funded. The next five data fields identify project

responsibility at the field activity level as well as the sponsor level. This is followed by two coded items which identify the project by sponsoring service and type of work. The project start date and expected project completion date are provided. Finally, improvement and modernization of facilities which are necessary for successful completion of the test and evaluation project are identified.

The information provided in this block allows the data to be sorted in various ways which may be of interest to management. The magnitude of direct workload associated with any of the fields in this block may be determined. For example, determination may be made of the direct workload funded by a particular appropriation, funded under a particular program element or sponsored by a particular NAVAIR program manager in any fiscal year. Furthermore, it is noted that, since the first five spaces in the project title represent the weapon system, aircraft designation or aircraft system component which constitute the primary reason for the project, total direct workload associated with a particular system program may be determined.

It is noted that some of the project details may not be known for future projects. In these cases, "educated guesses" may be made, or the data may be omitted. As the information becomes known, it may be entered or corrected as appropriate. This procedure has proved to be adequate for planning in the outyears.

3. Direct Workload Requirements by Function and Fiscal Year

To facilitate identifying direct workload requirements for current and anticipated projects, it is expedient to break the total effort down into specific functions. Consequently, as a result of consultation with functional area managers, the direct project effort at the Naval Air Test Center has been categorized into the following nineteen functions:

1. Air vehicle testing
2. Mission systems testing
3. Systems reliability, maintainability, and integrated logistic support evaluation
4. Aircraft maintenance
5. Electromagnetic compatibility testing
6. Electrical and environmental system testing
7. Ground support equipment testing
8. Ordnance systems testing
9. Aircrew systems testing
10. Electronic warfare systems testing
11. Carrier suitability testing
12. Communications, navigation, identification systems testing
13. Airborne test instrumentation design and installation
14. Range operations
15. Telemetry systems operations
16. T&E computational services
17. Test instrumentation services
18. Technical information services
19. Facility support.

These functions are shown in block 2 of figure 1. It is noted that, although the functions listed in this block were applicable to the Naval Air Test Center at the time this study was initiated, each MRTFB activity would be expected to list functions applicable to its unique mission. Furthermore, as the activity's functions are redefined as a result of possible changes in emphasis in its mission, changes may

be made to the definitions of functions listed in figure 1 without requiring a change to the Workload Plan Management System software.

For each applicable function, the expected workload, in direct manyears, is entered in the appropriate FY column for civilian, military, and/or contractor labor as appropriate. Also, the cost center (cc) in which the work will be conducted is noted. These data not only provide overall workload requirements, but also alert management as to which cost centers and specific functions are expected to have the heaviest or lightest load. Thus, in planning for future staffing requirements, management may be aware of which skills will be required and where they will be required.

4. Aircraft and Flight Hour Requirements

Required aircraft and estimated required flight hours are provided in block 3 for the appropriate fiscal years. Accurate data in this block will allow the activity and the Naval Air Systems Command to plan for allocation of required aircraft resources.

5. Funding Requirements

Funding requirements are classified in eight categories as shown in figure 1. These data are provided to justify project costs to the sponsor, and to provide data for budget preparation and fiscal planning in the outyears. Provisions are provided to identify the portion of the funds which will be passed to other activities for assistance in the prosecution of the project. It is noted that

the funding data are arranged to show what portion of the total funds are in support of direct workload.

6. Data Retrieval and Utilization

The primary uses of the Workload Plan Management System are to provide data for the annual Field Activity Plan required by the Naval Air Systems Command, to provide data to justify data provided for the annual POM cycle, to provide a basis for budget preparation, and, perhaps most significant, to provide information for analysis which may enable management at the activity level as well as the Systems Command level to make optimum decisions relative to staffing and project planning. Some examples of direct workload data which may be retrieved from the system are presented in Appendix A and are discussed in the following paragraphs.

The Workload Plan (p. 80) presents, for each active and forecasted project, a summary of workload information, including required direct manyears of effort and funding requirements. These summaries are forwarded to the Naval Air Systems Command as an appendix to the Field Activity Plan. They are also distributed to the activity cost centers responsible for the prosecution of the projects. The Workload Plan summaries allow the project sponsors and the activity managers to review the overall workload plan on specific projects, working from the same data base. In this manner, program managers, test and evaluation managers, and project personnel may coordinate planning on particular projects.

Total direct manpower requirements, sorted by civilian, military and contractor manpower, (p. 81) provide management with an overview of aggregated workload requirements for the entire activity by fiscal year. In addition, since manpower associated with aircraft maintenance is critical in respect to aircraft resources, this function is broken out as a separate item.

Manpower requirements by fiscal year, sorted by cost center and by function (pp. 82 and 83, respectively), allow management to detect any trends or shifts in workload concentration by cost center or required skills. For optimum utilization of personnel it is important that the available personnel with specific skills are assigned to the cost centers where the greatest need exists. To provide detailed information in this regard, data may be obtained which present workload requirements by fiscal year for a specific function within a particular cost center. One page of such a report is shown in Appendix A (p. 84) in which workload requirements in mission system testing, broken down by assigned and anticipated projects, are presented for cost center SA (Strike Aircraft Test Directorate). A complete report of this nature for all functions and cost centers could greatly enhance overall assignment of the right kinds of resources.

A direct funding summary (p. 85) shows total expected user/direct funds, by fiscal year, for each cost center. These data are also provided in the form of user/direct funds

detail, a sample page of which is shown in Appendix A (p. 86). This report shows expected user/direct funds, by fiscal year, sorted by specific projects, and is utilized by the comptroller's office for preparation of the annual budget.

C. FURTHER DEVELOPMENT OF WORKLOAD MEASUREMENT TECHNIQUES

The workload measurement techniques described above are sufficiently flexible to be adaptable to all Navy MRTFB activities, and to fit changing conditions within a given activity. Furthermore, they are amenable to improvements and modifications to increase the range of application and utilization.

Currently, workload data are processed through a batch processing input/output operation. In addition, an on-line information retrieval system is utilized for gathering data in response to specific inquiries to solve unique managerial problems.

Further development of the automatic data processing system associated with the Workload Plan Management System is required to make the system more responsive to management needs. An interactive on-line remote mode would allow users of the system to communicate with the system at remote terminals placed at strategic locations throughout the activity. Thus, data may be entered into the system and outputs may be retrieved as required. With the on-line remote operation, the current batch processing mode would not be discarded. The proposed plan is to retain the batch

processing input/output operation (utilizing the Workload Planning Data form shown in figure 1) for the major annual update, and utilize the on-line remote mode for additional inputs during the year, and for special data retrieval as required. It is anticipated that the most significant use of the on-line remote mode would be for special data retrieval to help solve unique managerial problems as they arise.

If the Workload Plan Management System is adopted throughout the Navy MRTFB, remote terminals would be placed at the Naval Air Systems Command (AIR-06). In this manner, the system could be queried directly from the Naval Air Systems Command for immediate retrieval of required workload and resource planning information. Consequently, the requirement for formal reports (specifically the Field Activity Plan) would be reduced, since the data would be obtainable more expeditiously through the Workload Plan Management System.

Additional developments include modification of the Workload Plan Management System software to make the system compatible with other automatic data processing systems. This would allow for more universal application of the system. Integration with current and/or proposed manpower staffing systems would allow workload requirements to be converted directly to manpower staffing requirements. Integration of the Workload Plan Management System with the Standard Automated Financial System STAFS) currently being developed for all NIF RDT&E activities [Ref. 16] would

enhance workload management by providing feedback and controls to facilitate direct monitoring of the validity of the planning data. These objectives are compatible with the following two objectives of STAFS as stated in Ref. 16:

> To provide a means by which management can compare actual performance to budget plans.
>
> To provide for automated interfaces with related systems.

Prototyping of STAFS is scheduled to commence on 1 October 1980. Implementation at the RDT&E activities will be initiated on 1 October 1981, and completed on 30 September 1982.

IV. ANALYSIS OF WORKLOAD AND RESOURCE REQUIREMENTS

A. MANPOWER REQUIREMENTS

1. Discussion

The ultimate purpose of workload management and planning is to provide a basis for resource management and planning. Three primary resources required by a MRTFB activity are manpower, facilities, and funding. Of these, manpower is considered the most significant since it is the manpower which constitutes the workforce through which effort is applied for accomplishment of the workload. The facilities represent the tools required by the workforce to accomplish the work, and funding is required to keep the workforce employed. Consequently, the primary concern is to convert workload into manpower requirements. The importance of manpower management and manpower analysis within an organization, as well as the difficulties of the task, are well recognized as exemplified by the following statement by Bonham, Clayton, and Moore [Ref. 17]:

> In essence, the organization must predict the future demand for manpower. This is not a simple task since some of the elements influencing the manpower requirements...are external to the organization and, therefore, not controllable by the decision maker.

The difficulties involved in converting workload to manpower requirements at a MRTFB activity are further complicated by the "three-dimensional" nature of the workforce: civil service, military, and contractor. Each of these components of the total workforce is governed by a unique

set of regulations, restrictions, and funding procedures; however, they all play important roles in the overall accomplishment of the activity's total workload. Consequently, the problem evolves into one of determining, not only the overall manpower requirements, but the optimum mix of civil service, military and contractor manpower.

It is noted that this analysis is concerned with "aggregate planning" models, which deal with categories of personnel, rather than "assignment" models, which deal with individual employees [Ref. 12]. The aggregate planning models developed in this analysis are intended to serve as the basis for assignment models which deal with manpower allocation to achieve the desired staffing plan. Such manpower allocation models have been developed by Buffum [Ref. 18]. Mavrikas [Ref. 19] developed an algorithm for implementing these models by the use of mixed integer linear programming.

2. Linear Manpower-Workload Model

For the purpose of devising a relatively simple but reasonably accurate model for manpower-workload analysis, the total manpower requirement is assumed to be a linear function of direct workload. This assumption is considered to be valid for the relevant range of workload under consideration. Consequently, the relationship between the total manpower requirement and direct workload may be expressed by the linear equation:

$$y = a + bx$$

in which the independent variable x represents workload in direct manyears and the dependent variable y represents the total manpower requirements. The manpower-workload model based on this linear relationship is represented graphically in figure 2. In this model, the workforce is depicted as consisting of three categories of manpower: fixed indirect, variable indirect and direct. The fixed indirect manpower, represented by the constant, a, the intercept in figure 2, includes all manpower performing general and administrative functions such as staff, support, and service functions (designated as general cost centers). The variable indirect manpower includes all manpower performing indirect tasks in support of the direct workload, and would be located in the operating areas (direct cost centers). The constant, b, the slope of the line in figure 2, represents the ratio of the total variable manpower to the direct manpower. The constants, a and b, may be estimated for a particular activity by using historical accounting data. After the constants have been determined, it is then possible to determine total manpower requirements from forecasted workload.

The manpower-workload profile for the Naval Air Test Center was computed from FY 1979 labor distribution data. During the analysis of these data, it became apparent that the civil service, military, and contractor manpower should each be treated as a separate and distinct workforce, each with its unique constants. Thus, an MRTFB activity is envisioned as a complex workforce consisting of three separate

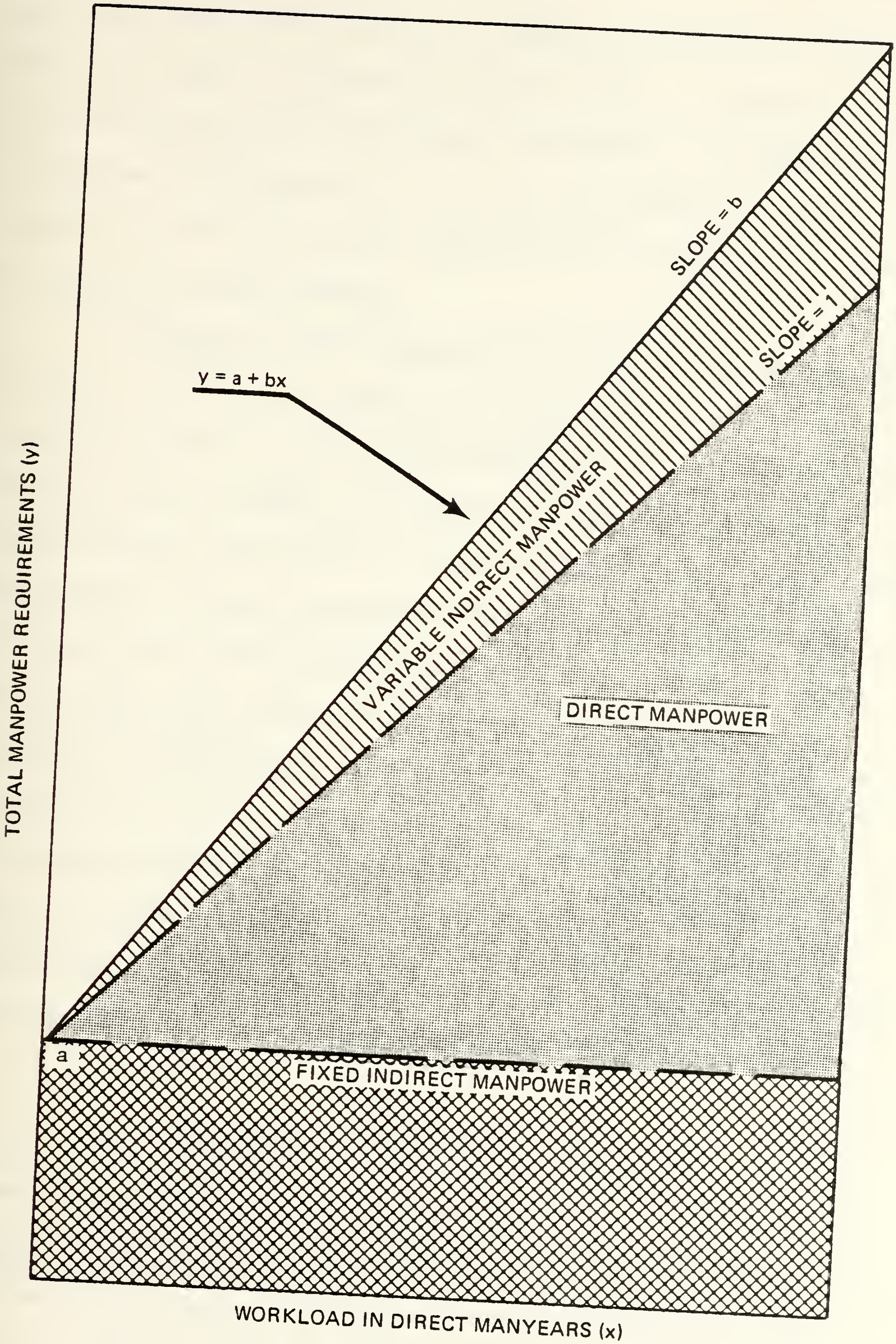

FIGURE 2
LINEAR MANPOWER-WORKLOAD MODEL

workforces, each performing its unique functions to accomplish the overall workload of the activity. Specific tasks may be shifted between the three workforces to compensate for manpower shortages in a particular workforce and/or achieve the most effective combination of talents for overall mission accomplishment.

A summary of the manpower distribution data is presented in Table II, in which the constants, a and b, are computed for each of the three workforces. In compiling the data utilized in Table II, labor distribution manyears charged against job orders funded by user/direct funds were designated as direct; manyears charged against job orders funded by the institutional fund were designated as fixed indirect when the work was performed in a general cost center and variable indirect when the work was performed in a direct cost center. The data tabulated in Table II are presented graphically in figure 3. The "three-dimensional" manpower-workload profile of figure 3 may be utilized for determining the size of each of the three workforces required to accomplish the forecasted workload. It may also be

TABLE II

MANPOWER DISTRIBUTION DATA
FOR THE NAVAL AIR TEST CENTER (FY 79)

WORKFORCE	FIXED INDIRECT MANPOWER (a)	DIRECT MANPOWER	VARIABLE INDIRECT MANPOWER	TOTAL VARIABLE MANPOWER	VARIABLE RATIO (b)	TOTAL MANPOWER
CIVILIAN	1305	737	270	1007	1.37	2312
MILITARY	715	425	202	627	1.48	1342
CONTRACTOR	100	312	78	390	1.25	490
TOTAL	2120	1474	550	2024	1.37	4144

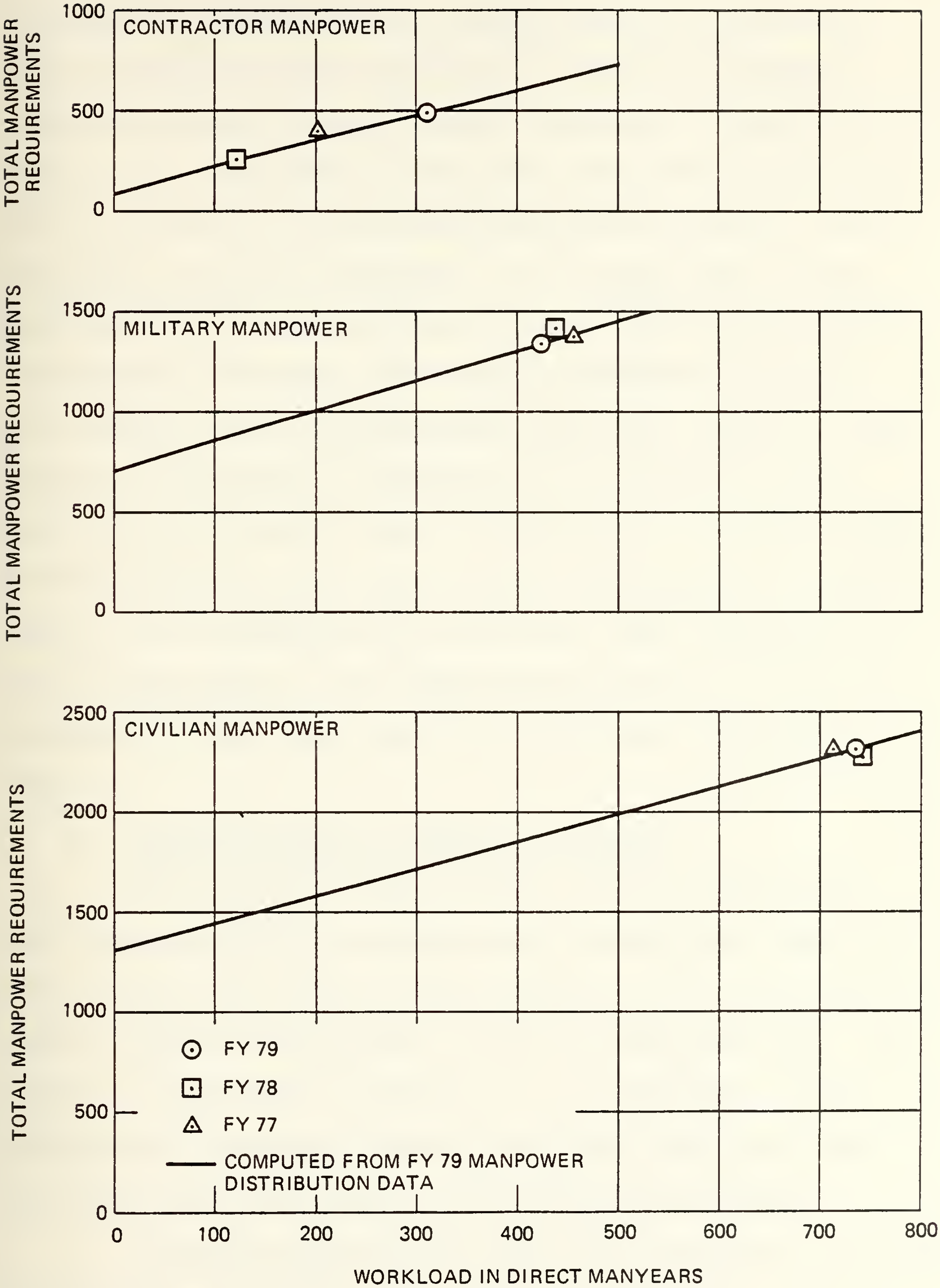

FIGURE 3
"THREE DIMENSIONAL" MANPOWER-WORKLOAD
PROFILE FOR THE NAVAL AIR TEST CENTER

utilized for determining the overall effect of shifting direct workload between workforces. The total manpower-workload profile for the combined workforce is presented in figure 4 for information. Data from the three fiscal years (FY 77 through FY 79) have been plotted on figures 3 and 4, and appear to follow the model. It is noted that, since staffing policies may vary over time, especially in regard to assignment of support and general overhead functions, the constants used in establishing the model should be continually reevaluated. Furthermore, the accuracy of the model can be no better than the accuracy of the labor distribution data from which the constants are computed. Consequently, it is important that accurate labor distribution data be maintained at the MRTFB activities for all three components of the total workforce, including contractor labor.

3. Workforce Planning Based on Workload

After the projected workload for an activity has been determined, and a suitable manpower-workload model has been devised, the problem then becomes one of formulating a viable workforce plan based on the projected workload. The process, as depicted in figure 5, is an iterative one of matching the available "three-dimensional" workforce with the requirements dictated by the predicted workload.

Projected workload must first be converted to required civil service, military, and contractor manpower. These are then compared with the available manpower. If the available

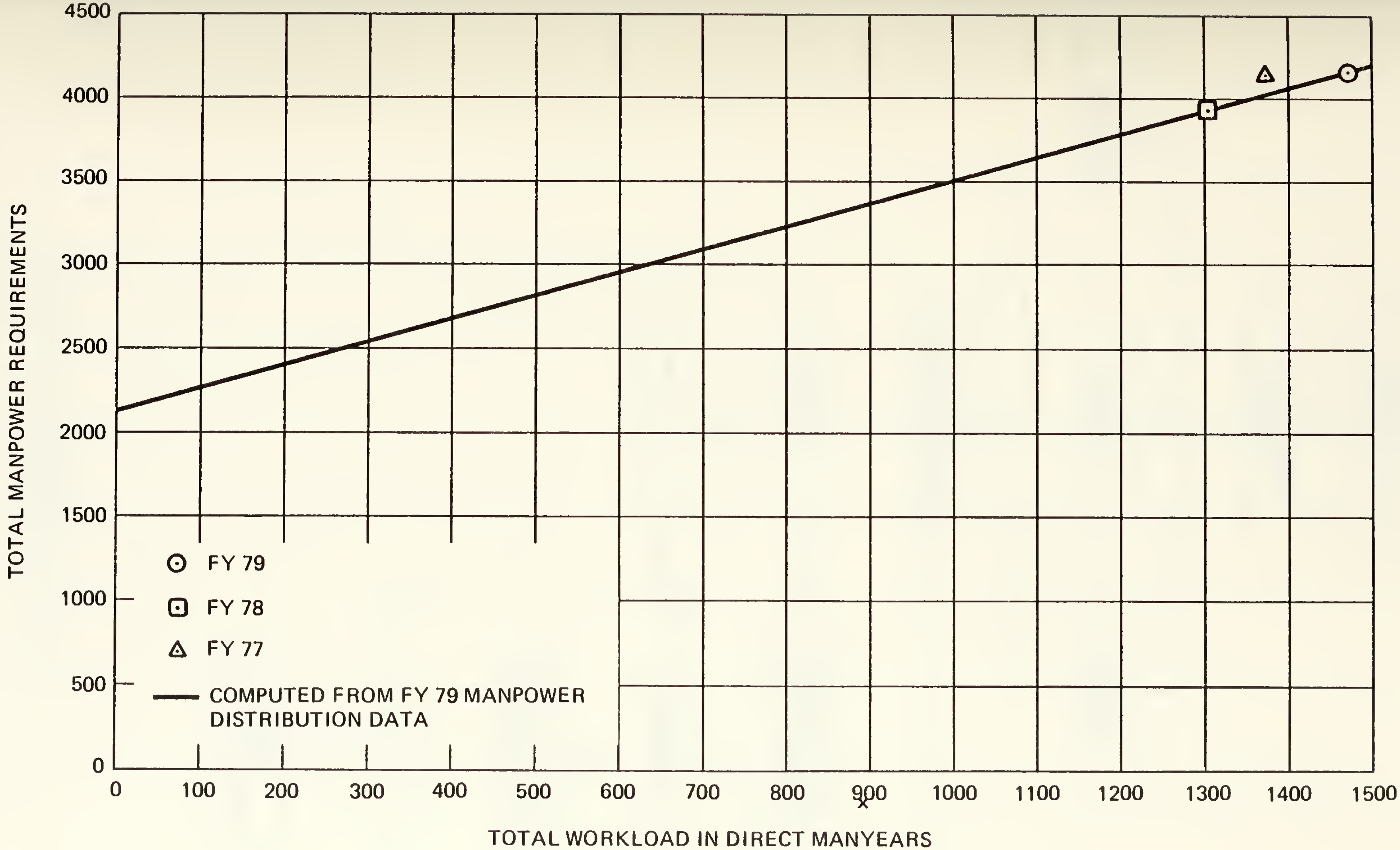

FIGURE 4
TOTAL MANPOWER-WORKLOAD PROFILE
FOR THE NAVAL AIR TEST CENTER

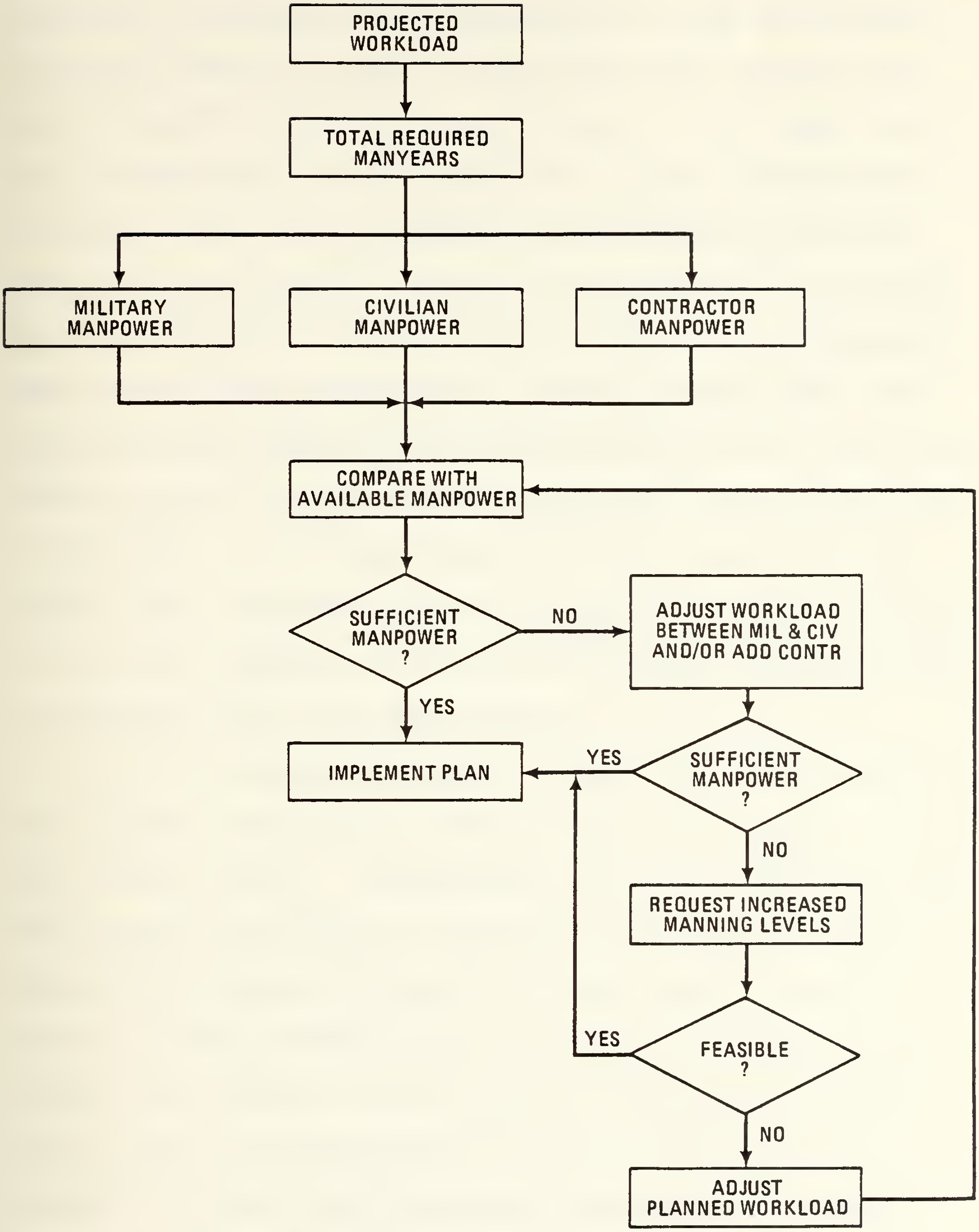

FIGURE 5
ALGORITHM FOR CONVERTING PROJECTED
WORKLOAD TO WORKFORCE PLANNING

manpower, in either of the components, is not sufficient, an attempt should be made to adjust the work between the three components, contracting out more of the direct workload if feasible. If shortages still exist, requests for increased civil service ceilings and/or military manning levels should be made. If this is unsuccessful, an adjustment must be made to the planned workload; i.e., management must decide which projects will not be accomplished. The comparison-adjustment process is an iterative one, and should continue until a match between requirement and availability is achieved. It is noted that, for the process to be an orderly one, the analysis must be made far enough in advance to allow for appropriate actions to be taken systematically in accordance with the PPBS process.

It is suggested in Ref. 13 that tight constraints have "largely negated the value of the unconstrained five-year activity plan." Consequently, the five year workload plan has been discarded at the Naval Ship Weapons Systems Engineering Station in favor of a short range, one year planning document based strictly on current budgetary and manpower constraints. This action is considered inappropriate since an unconstrained five year workload plan is necessary to keep higher management informed of resource requirements and to justify future budgetary needs. Only by determining and reporting unconstrained projected workload can the variance between actual requirements and budgets be brought to the attention of higher management, and

unaccomplished workload, resulting from imposed constraints, be highlighted.

4. Optimum Workload

Determination of a MRTFB activity's workload capacity is a difficult task. A basic problem in this regard is the frequent lack of differentiation between capacity and capability. These two terms are two separate and distinct characteristics of an activity. The activity's capability refers to the assemblage of expertise, skills, talents, technical facilities, physical plant, and support facilities and equipment required to accomplish its assigned mission. It must be assumed that workload assignments are directed to the activity having the mission responsibility and capability as required by Ref. 9. An activity's workload capacity is a measure of the quantity of work that an activity is capable of accomplishing at any given time. This factor is a function of many variables; e.g., physical plant size, quantity and quality of facilities, size of the workforce, office spaces, laboratory spaces, hangar spaces, etc. Because of the innumerable variables involved, and the unstructured nature of the work performed, it is not considered possible to express workload capacity for a MRTFB activity in explicit, definitive terms. It is considered possible, however, to determine the optimum workload for effective utilization of the workforce at a MRTFB activity.

It is hypothesized that a functional relationship exists between the optimum workload for a MRTFB activity and the size of the fixed indirect workforce required for support,

service, and general and administrative functions. In other words, the "size" of an activity, and therefore its optimum capacity to prosecute direct workload, may be measured by the size of the workforce required to operate, maintain and administer it.

In order to determine the optimum workload for a MRTFB activity, a new parameter, manpower utilization factor (u), is defined as the ratio of direct to total manpower, and is represented by the expression:

$$u = \frac{x}{a + bx}$$

in which the variable x is direct workload in manyears and the constants a and b are defined as before. A typical plot of the manpower utilization factor as a function of workload in direct manyears is presented in figure 6. The optimum workload for effective utilization of the workforce may now be defined as the workload, in direct manyears, at which the optimum manpower utilization factor occurs. In referring to figure 6, the optimum workload would occur in the vicinity of the "knee" of the curve, beyond which large increases in direct workload would result in relatively small increases in manpower utilization factor. If the direct workload is decreased below the region of optimality, the manpower utilization factor decreases rapidly to the point at which the workforce is utilized primarily to keep the activity open.

Given the fixed indirect manpower, a, and the variable manpower ratio, b, of a MRTFB activity, the optimum

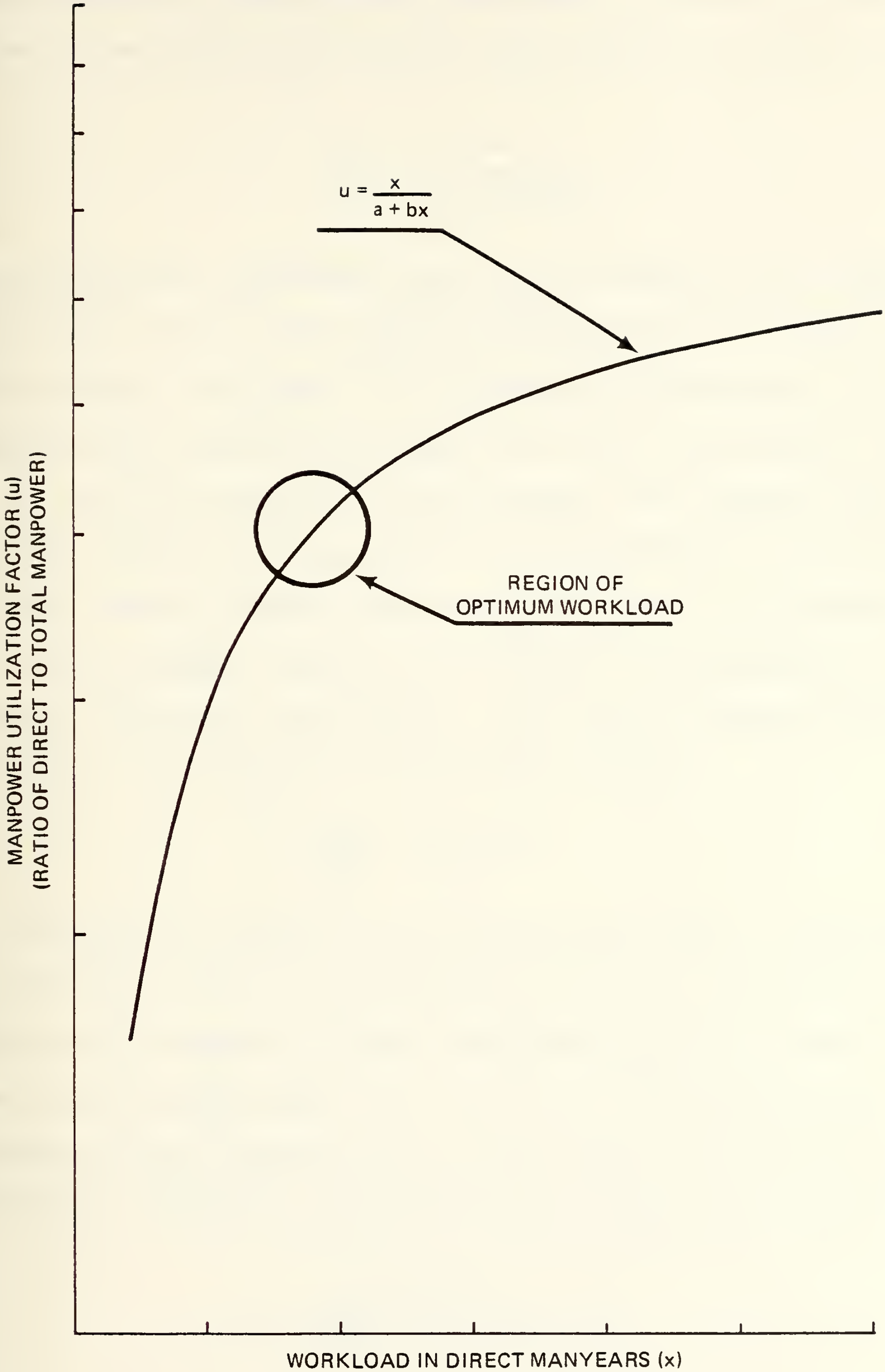

FIGURE 6
MANPOWER UTILIZATION FACTOR VERSUS WORKLOAD
SHOWING REGION OF OPTIMUM WORKLOAD

workload can be definitively determined by taking the derivative of the utilization factor with respect to direct workload:

$$\frac{du}{dx} = \frac{a}{(a + bx)^2}$$

This derivative represents the rate of change of the manpower utilization factor with direct workload, and is plotted, for illustration, in figure 7 as a function of workload in direct manyears for a particular value of a, and a particular value of b. For the purpose of this analysis, the optimum workload for effective utilization of the workforce is defined as that value of direct workload above which an increment of 50 direct manyears results in a change in the manpower utilization factor of less than 1%. The rate of change corresponding to the optimum workload then becomes:

$$\frac{du}{dx} = 2 \text{ X } 10^{-4}$$

By referring to figure 7, it is noted that this is the value at which the rate of change of the manpower utilization factor with respect to direct workload begins to level off. Now by setting $\frac{du}{dx}$ equal to 2 X 10^{-4} and designating the optimum direct workload as x* in the above derivative, the following expression is derived for optimum direct workload:

$$x^* = \frac{1}{b}\left(\sqrt{\frac{a}{2 \text{ X } 10^{-4}}} - a\right)$$

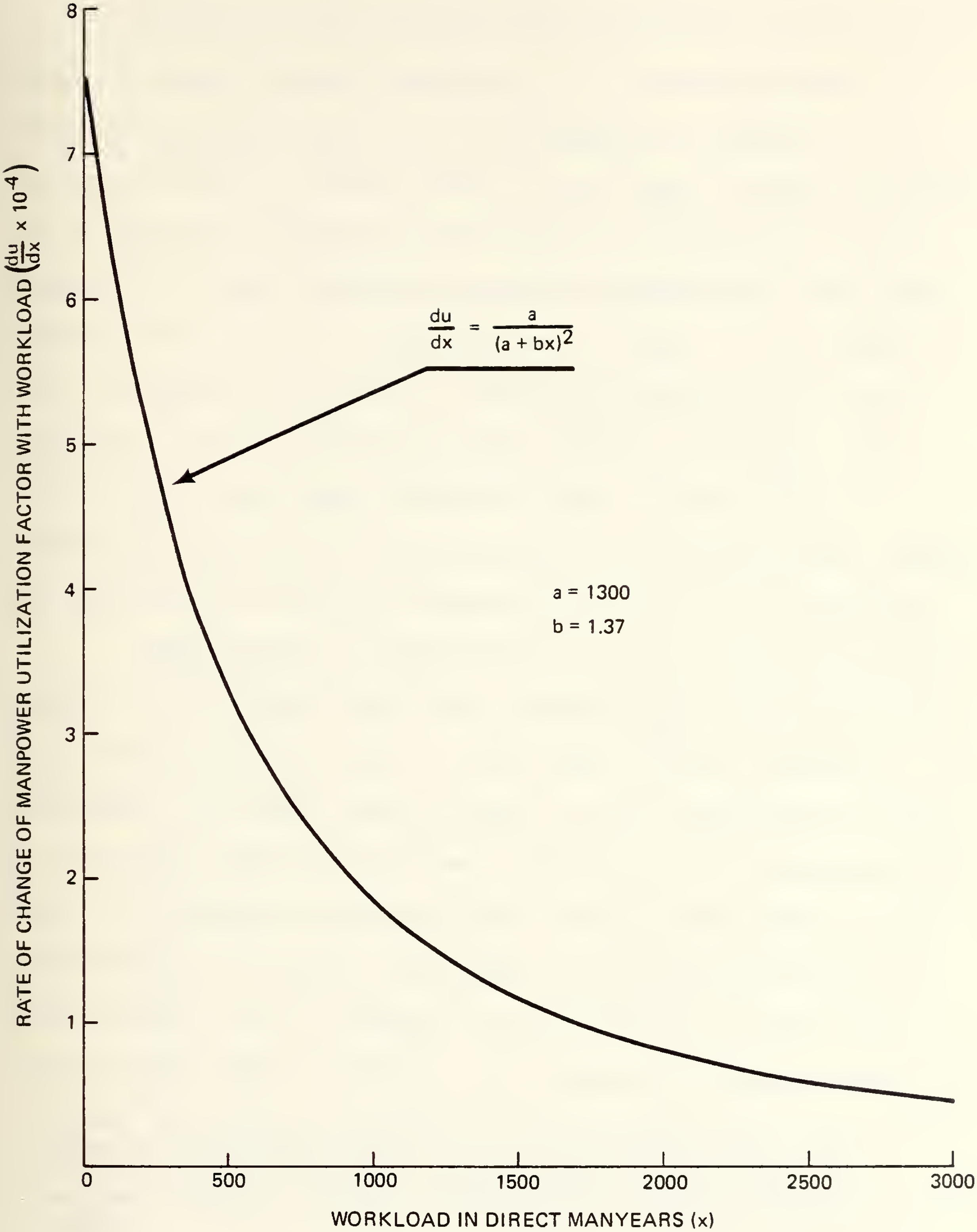

FIGURE 7
GRAPHICAL REPRESENTATION
OF THE RATE OF CHANGE OF
MANPOWER UTILIZATION FACTOR
WITH WORKLOAD

A plot of the optimum direct workload, x*, as a function of fixed indirect manpower, a, for various values of variable manpower ratio, b, is presented in figure 8. By entering figure 8 at the value of the fixed indirect manpower for a particular workforce, the optimum workload in direct manyears for that workforce may be determined for the appropriate value of the variable manpower ratio. It is noted that a separate value of x* should be determined for each component of the workforce (civil service, military, and contractor). The total optimum direct workload for an activity would then be the total of the optimum direct values determined for the three components of the total workforce.

Examination of figure 8 reveals an interesting phenomenon. It is noted that the optimum direct workload does not continuously increase as the fixed indirect manpower increases. In other words, bigger is not necessarily better. As the fixed indirect manpower increases beyond approximately 1300, the optimum direct workload actually decreases as the fixed indirect manpower increases. This is apparently a manifestation of the economic law of variable proportions (law of diminishing returns). As stated by Douglas [Ref. 20]:

> Sooner or later, as units of the variable factor are added to the fixed supply of capital resources, the marginal product of the variable factor must begin to decrease, due to simple overcrowding if for no other reason.

Figure 9 is a presentation of the manpower utilization factor as a function of workload in direct manyears for various values of fixed indirect manpower, and constant variable

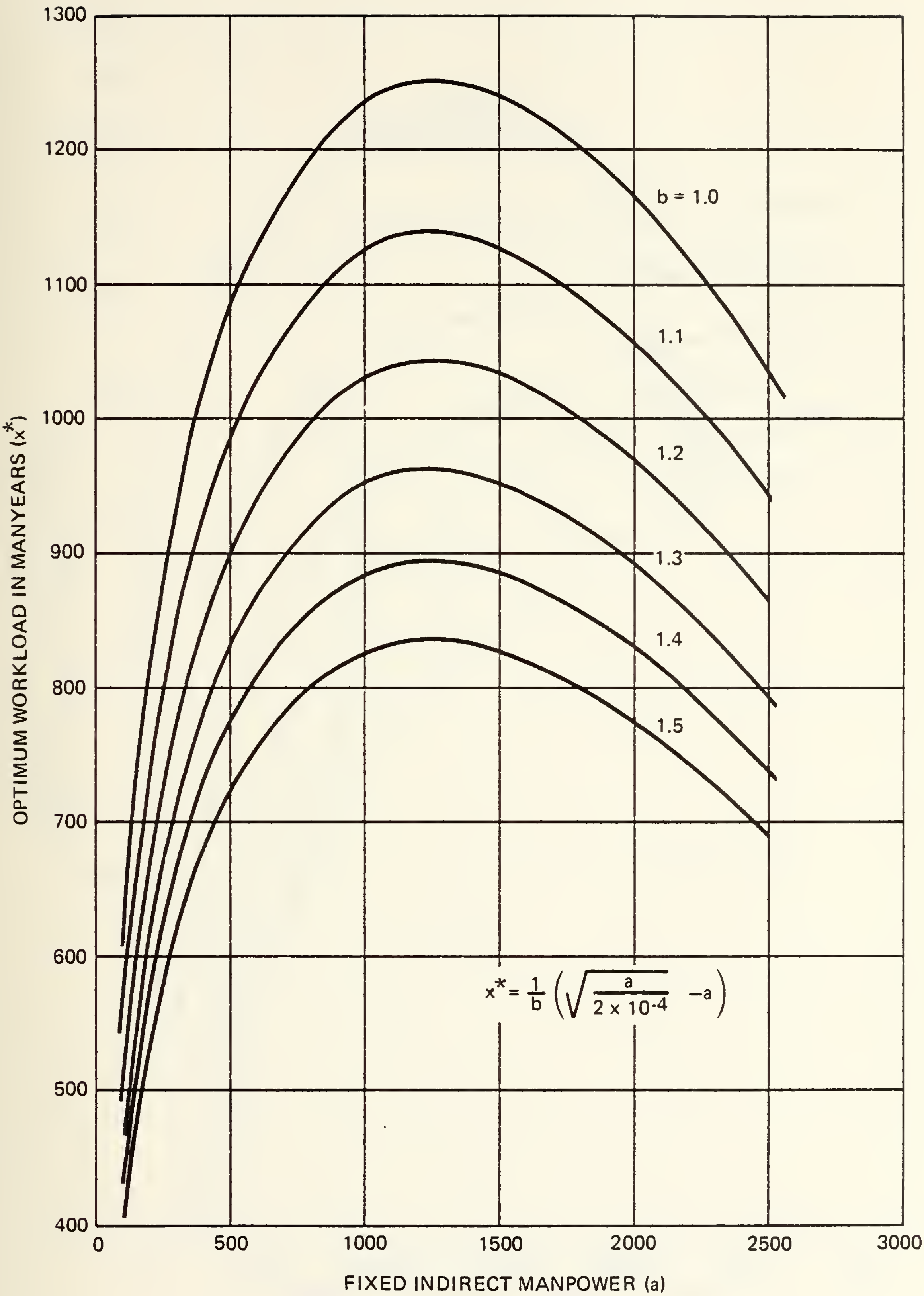

FIGURE 8
OPTIMUM WORKLOAD AS A FUNCTION OF
FIXED INDIRECT MANPOWER AND VARIABLE
MANPOWER RATIO

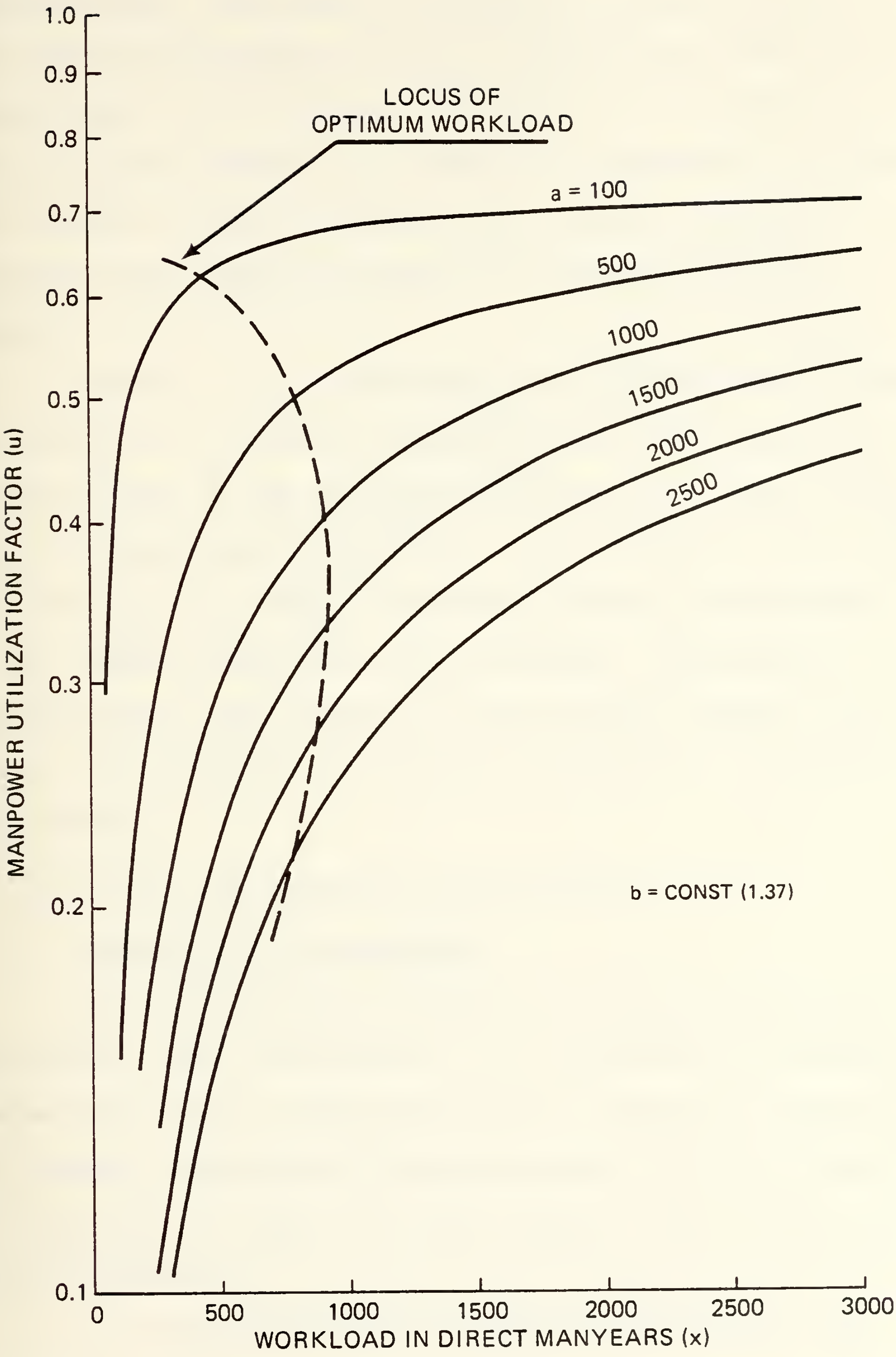

FIGURE 9
THE EFFECT OF FIXED INDIRECT MANPOWER
ON MANPOWER UTILIZATION FACTOR AND
OPTIMUM WORKLOAD

manpower ratio. The locus of optimum workload plotted on this graph illustrates the law of diminishing returns discussed above. It is further noted that, at low values of fixed indirect manpower, the region of optimality is rather well defined; however, as the fixed indirect manpower increases, the region of optimality becomes less well defined.

Figure 10 is a presentation of the manpower utilization factor as a function of workload in direct manyears for various values of the variable manpower ratio, and constant value of fixed indirect manpower. It is noted in this case that the locus of optimum workload increases continuously as the variable manpower ratio decreases. This should be expected since lower values of the variable manpower ratio imply more effective utilization of manpower in the direct cost centers.

B. FACILITIES REQUIREMENTS AND UTILIZATION

1. Factors to be Considered

After the manpower required to perform the projected workload has been determined, it is necessary to determine whether the physical facilities at the activity (laboratories, test ranges, assemblage of test equipment, etc.) are adequate to accomplish the work. In this respect, three factors are to be considered:

a. The capability of current facilities at the activity.

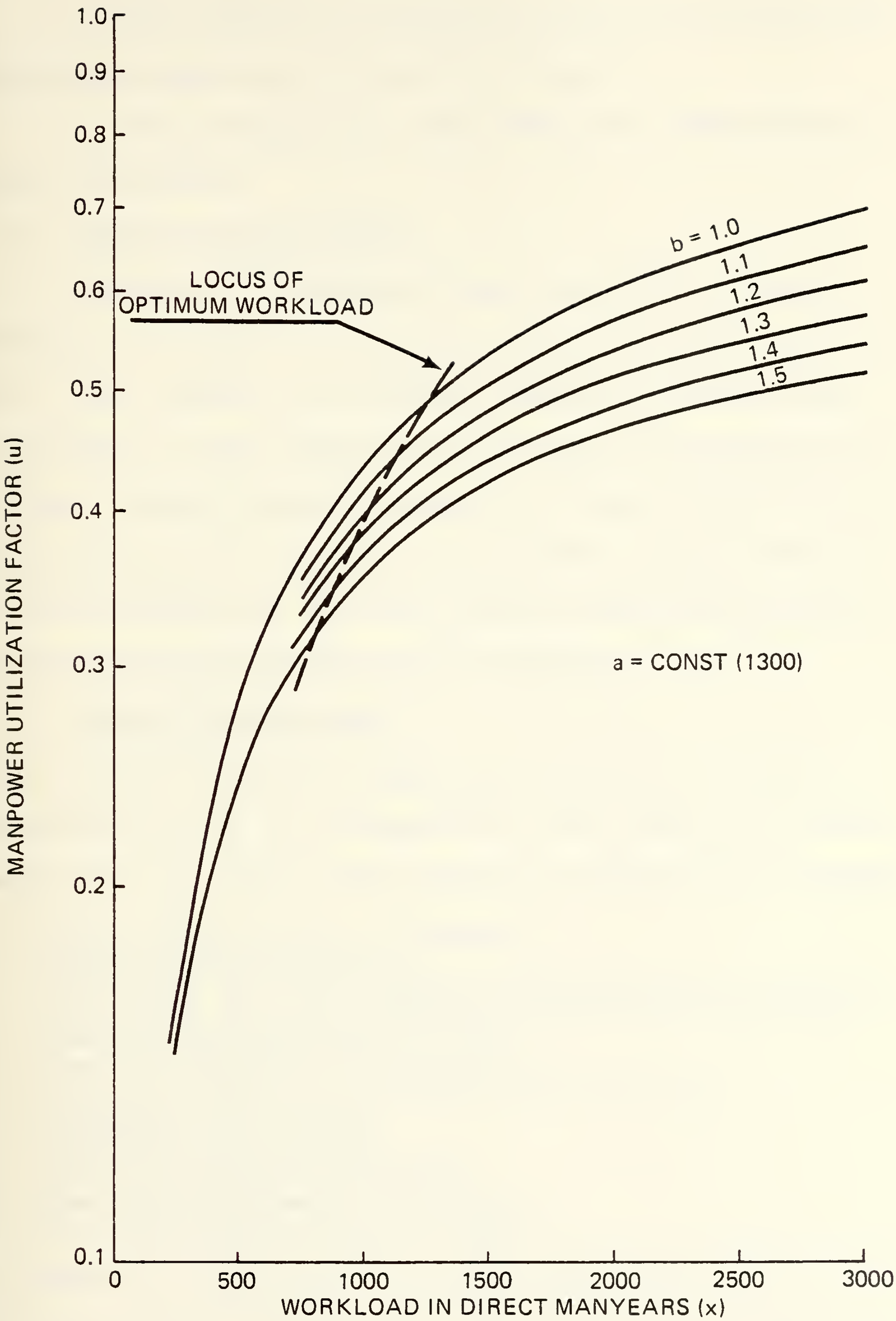

FIGURE 10
THE EFFECT OF VARIABLE MANPOWER RATIO ON MANPOWER UTILIZATION FACTOR AND OPTIMUM WORKLOAD

b. The degree of utilization of current facilities dictated by current and projected workload.

c. Requirements for improvement and modernization of test facilities.

2. Facility Capabilities

The Naval Air Systems Command (AIR-06) currently maintains a register of all test facilities within the Navy MRTFB. This register is currently being revised and will be published as the "NAVAIR T&E Facilities and Capabilities Handbook." Thus, potential sponsors of test and evaluation workload will have a comprehensive guide to assist them in directing projects to the Navy activity having the mission responsibility and capability as required by Ref. 9.

3. Facility Utilization

For the purpose of determing facility utilization, the test facilities at the Naval Air Test Center have been categorized into twelve major facility complexes as follows:

1. Mission Systems Test Laboratory
2. Acoustic Test Facility
3. Electronic Warfare Integrated Systems Test Laboratory
4. Electrical and Environmental Systems Test Facility
5. Ordnance Systems Test Facility
6. Electro-Optical Test Facility
7. Aircraft Catapult and Arrest Test Facility
8. Chesapeake Test Range
9. Telemetry Data Center
10. Central Scientific Computer
11. Test Instrumentation Facility
12. Electronic Systems Test Facility

Each MRTFB activity would, of course, have its own list of major facilities. Furthermore, the list of major facilities at a particular activity would be expected to change, over time, as the test facilities are improved and modernized.

Utilization of facilities for MRTFB activities is currently reported in the Field Activity Plan in terms of total hours of operation per year. The same parameter is used as a measure of workload in the annual MRTFB budget. Total hours of operation of a facility is not considered a suitable measure of facility utilization; nor is it suitable as a measure of workload. In order to adequately measure facility utilization, the unit of measure should be related to the function performed by the facility. Since each facility performs a unique function, each would require a different parameter for measuring utilization. For example, for a test range, the total aircraft flight hours on the range may be appropriate; for the aircraft catapult and arrest test facility, the number of launches and arrestments; etc. The appropriate measure of workload related to a test facility is the total direct manhours required for operation of the facility in support of projects funded by user/direct funds.

A proposed format for reporting facility utilization and workload for incorporation in the Field Activity Plan and the MRTFB budget is presented in figure 11. This form would be prepared for each major facility identified by the reporting MRTFB activity. The first three items on the form identify the reporting activity and date of submission, the major facility reported on, and a brief description of the facility. In the description of the facility, reference to applicable sections of the NAVAIR T&E Facilities and Capabilities Handbook would be appropriate to provide a source of a

FACILITY UTILIZATION AND WORKLOAD

1. ACTIVITY: ______________________________ DATE: __________

2. MAJOR FACILITY: ______________________________

3. DESCRIPTION:

4. FACILITY UTILIZATION:

   a. RELEVANT VARIABLE: ______________________________

   b. UNIT OF MEASURE: ______________________________

   c. MAX UTILIZATION (UNCONSTRAINED MANPOWER): ______________

   d. MAX UTILIZATION WITH CURRENT MANPOWER: ______________

   e. PLANNED FACILITY UTILIZATION:

	CURRENT FY	BUDGET FY	BUDGET FY+1
UTILIZATION (UNITS OF REL. VAR.)			
% UTILIZATION (UNCONSTRAINED MANPOWER)			
% UTILIZATION (CURRENT MANPOWER)			

5. FACILITY WORKLOAD:

	CURRENT FY	BUDGET FY	BUDGET FY+1
DIRECT MANYEARS OF EFFORT FOR OPERATION OF FACILITY IN DIRECT SUPPORT OF PROJECTS FUNDED BY USER/DIRECT FUNDS.			

6. OPERATIONAL CONSTRAINTS:

7. MANPOWER CONSTRAINTS:

8. NARRATIVE:

FIGURE 11
PROPOSED FORMAT FOR REPORTING FACILITY UTILIZATION AND WORKLOAD

more detailed description. Item 4 presents information pertaining to facility utilization. The relevant variable appropriate for the specific major facility would be listed (e.g., for a range, total aircraft time on the range). This would be followed by the appropriate unit of measure of the relevant variable (e.g., flight hours). It is noted that several variables may be identified as relevant for the operation of a particular facility; however, the variable to be selected would be one which would most likely have a limiting effect on the utilization of the facility. The maximum utilization per year possible, in terms of units of the relevant variable, would then be determined, based on unconstrained manpower and based on current manpower (the constraints and assumptions upon which these figures are based would be defined in items 6 and 7). The planned utilization of the facility would then be tabulated for the current year, budget year, and budget year plus one. These data would be presented in terms of units of the relevant variable, and percent of maximum utilization based on unconstrained manpower and current manpower. Item 5 presents planned workload, for the current year, budget year, and budget year plus one, in terms of direct manyears of effort required for operation of the facility in direct support of projects funded by user/direct funds. These data would be extracted from the Workload Plan Management System. Item 6 presents the operational constraints and assumptions which dictated the maximum utilization provided in item 4.c.

(e.g., expected weather conditions, average daylight hours, preventive maintenance, number of hours per working day, number of shifts, overtime, etc.). Item 7 presents the manpower requirements to achieve the maximum utilization of item 4.c., and the current manpower which dictates the maximum utilization provided in item 4.d. Item 8 provides space for narrative information which may further describe constraints in more detail, and/or provide additional information pertinent to the utilization of the facility and workload associated with the operation of the facility.

Figure 11, when properly completed, would provide management with meaningful information pertaining to facility utilization and workload at the MRTFB activities. For example, the planned utilization in terms of percent or maximum utilization provides prospective workload sponsors an indication of the availability of the facility to accommodate additional projects (with current manpower, and if additional manpower were available). It is emphasized that the workload data apply only to that portion of the total direct workload required for operation of the specific facility. These data are included in the total workload data provided by the Workload Plan Management System as displayed in Appendix A.

4. Facility Improvement and Modernization

As the systems undergoing test and evaluation become more sophisticated, the current facilities at the MRTFB activities may become inadequate to perform the required tasks. Furthermore, facility utilization data may indicate

that additional facilities may be required to adequately prosecute the workload in certain technological areas. Consequently, each MRTFB activity has developed requirements for improvement and modernization projects. Each improvement and modernization project is coded, prioritized, and reported in the Field Activity Plan along with an issue paper justifying its requirement. It is noted in figure 1 that a field is provided in the Workload Planning Data input document (item 24) for the inclusion of related improvement and modernization projects which are required for the successful prosecution of the test and evaluation project. This type of data provides additional justification for funding required for improvement and modernization of test facilities at the MRTFB activities. It is noted that improvement and modernization of test facilities are funded by the institutional fund, not user/direct funds; however, workload generated by user requirements forms the basis for their requirement.

C. FUNDING REQUIREMENTS

The funding data provided by the Workload Plan Management System identify only direct funds; those funds necessary for the support of direct workload. These data are utilized for the preparation of the user/direct portion of the budget.

Under the Uniform Funding Policy, virtually all sponsors of direct work are required to reimburse direct costs only. Indirect costs, including those required for improvement and modernization of facilities and laboratories and those required

for indirect flight hours, are funded separately by the institutional fund. Although the institutional fund is not intended to be used for reimbursement of costs incurred in the accomplishment of direct workload, there is a causal relationship between direct workload and indirect costs funded by the institutional fund. For example, as illustrated in figure 2, the variable indirect manpower requirements (the cost of which must be reimbursed by the institutional fund) is a direct function of direct workload. Furthermore, direct workload generates the requirement for improvement and modernization projects, the cost of which, again, must be reimbursed by the institutional fund.

The relationship between direct and indirect costs at a MRTFB activity is delineated in the draft revision to Ref. 7 as follows:

> All costs will be assigned based on a beneficial or causal relationship which is consistently applied. Direct costs require specific identification to a job or function served. Indirect cost shall be screened into homogeneous cost pools having essentially the same relationship to the jobs or functions served and then allocated on a basis which best measures the relationship between the indirect cost pool and the jobs/functions.

Management must recognize the causal relationship between indirect costs and direct workload when the institutional budget is prepared. Furthermore, to ensure effective financial management at a MRTFB activity, this causal relationship must be taken into account in assignment of the institutional fund to the activity.

V. WORKLOAD PLANNING, FEEDBACK AND CONTROL

A. TACTICAL VS STRATEGIC PLANNING

Planning is traditionally categorized into long range planning, medium range planning, and short range planning. Long range planning is usually thought of as covering a time period of twenty years; medium range planning, between two and ten years (normally five years); and short range planning of one year or less. It is considered more appropriate, however, to define planning as strategic or tactical. Long range planning is often considered strategic; short range planning, tactical; and medium range planning, perhaps a combination of the two; however, this differentiation is not considered accurate. Although strategic planning usually covers a longer time frame than tactical planning, this is not necessarily true in all cases. Whether planning is strategic or tactical is dependent primarily upon the nature of the planning rather than the time frame involved.

Steiner [Ref. 21] presents the following definition of strategic planning:

> Strategic planning is the process of determining the major objectives of an organization and the policies and strategies that will govern the acquisition, use, and disposition of resources to achieve those objectives. Objectives in the strategic planning process include missions or purposes, if they have not been determined previously, and the specific objectives that are sought by a firm. Although the strategic objectives are usually long range, they can be short range.

Tactical planning, on the other hand, is defined as "the detailed deployment of resources to achieve the strategic plans."

The following are some of the significant distinctions between strategic and tactical planning listed by Steiner in Ref. 21:

> Strategic planning is more heavily weighted with subjective values of managers than is tactical planning.
>
> Uncertainty is usually much greater in strategic planning than in tactical planning. Not only is the time dimension much shorter in tactical than in strategic planning, but the risks are much more difficult to assess and are considerably greater in strategic planning.
>
> Strategic planning usually covers a long time spectrum but sometimes is very short, and varies from subject to subject. Tactical planning, in contrast, is of a shorter duration and more uniform for all parts of the planning program.
>
> Strategic planning is original in the sense that it is the source or origin of all other planning in an enterprise. In contrast, tactical planning is done within, and in pursuit of, strategic plans.
>
> It is usually considerably easier to measure the effectiveness and efficiency of tactical plans than of strategic plans. Results of strategic planning may become evident only after a number of years. Very frequently it is difficult to disentangle the forces which led to the results. In sharp contrast, tactical planning results are quickly evident and much more easily identified with specific actions.

Although definitive distinctions may be made between strategic and tactical planning, these distinctions often become rather nebulous in actual practice. This view is expressed rather clearly by Ackoff (Ref. 22]:

> The distinction between tactical and strategic planning is often made but is seldom made clear. Decisions that appear to be strategic to one person may appear to be tactical to another. This suggests that the distinction is relative rather than absolute. Indeed this is the case.

Steiner [Ref. 21] further expounds on the difficulties of attempting to definitively distinguish between strategic and tactical planning:

> Both conceptually and operationally, the lines of demarcation between strategic and tactical planning are blurred. At the extremes their differences are crystal clear as in the above comparison. But these distinctions do not always hold. For example, both in theory and practice, there is in planning an intricate ends-means chain. Strategy gives rise to tactics, and may be considered a substrategy which in turn employs tactics for execution. What is one manager's strategy is another's tactics, what is one manager's tactics is another's strategy.

In view of the above discussion, workload planning at the MRTFB activity level is considered to be tactical in nature. The planning and future allocation of resources at the activity may be considered strategic when viewed from the activity's point of view; however, as viewed from the perspective of the overall Navy MRTFB management level and systems acquisition strategy, workload planning at the activity is tactical in nature since the overall purpose is to effect optimum deployment of resources to achieve the objectives of the strategic plans. Workload planning is based primarily on extrapolation of currently assigned projects plus a forecast of anticipated projects resulting from current studies. Strategic factors such as assumptions concerning expected acquisitions and future programs are rarely quantifiably available to the workload planners and are usually not considered.

B. UNCERTAINTIES AND LIMITATIONS IN WORKLOAD PLANNING

Since strategic factors affecting future workload are external to the planning organization, there are numerous

uncertainties which must be taken into account when interpreting the planning data. As noted earlier, forecasts of future workload are based primarily on extrapolation of currently assigned projects and a forecast of future requirements for development test and evaluation. However, there is no assurance that the predicted projects will materialize; nor is there any assurance that, if the projects do materialize, they will be assigned to the planning activity. Although Ref. 9 specifies that "Navy test and evaluation workload assignments must be directed to the Navy activity having the mission responsibility and capability to support such assignments," the interpretation of "mission responsibility and capability" may change between the time of planning and the time of assignment of a particular project.

The major uncertainties associated with workload forecasting result from the difficulty in accounting for all of the strategic variables that may affect workload when an attempt is made to look into the future. The "crystal ball" becomes clouded beyond one or two years. Because of the uncertainties, it is postulated that the ability to forecast workload requirements diminishes as a function of the square of the time, in years, over which the forecast is made. Consequently, an expression for the reliability of workload planning derived from the ability to forecast workload requirements, based on current and projected programs, may be stated as:

$$R = 100 - t^2,$$

in which the reliability, R, is expressed in percent and t is the planning time in years. This relationship is depicted graphically in figure 12. According to this model, workload planning is possible with better than 90% reliability out to three years. Reliability then reduces to 75% in five years and to zero in ten years. As shown in figure 12, planning beyond ten years must be based solely on strategic assumptions concerning future development programs.

The planning reliability model depicted in figure 12 may be utilized effectively for the analysis of planned workload. For illustration, planning data for the Naval Air Test Center, adjusted for constraints, is presented in figure 13. As shown in the top graph of figure 13, an apparent decline in workload over the seven year planning period is indicated. However, when the planning reliability curve is superimposed on the planning data (bottom graph of figure 13), it is noted that the data follow, rather closely, the reliability curve, indicating essentially constant workload over the first three years. After the third year, the data diverges upward from the reliability curve, indicating an increase in workload between the third and fifth years. After the fifth year, the data again follow the reliability curve, indicating constant workload after the incremental increase between the third and fifth year. The overall effect is an expected increase in workload. Consequently, the Naval Air Test Center should be planning for an increase in workload over the seven year planning period, rather than a decrease as indicated by the raw data.

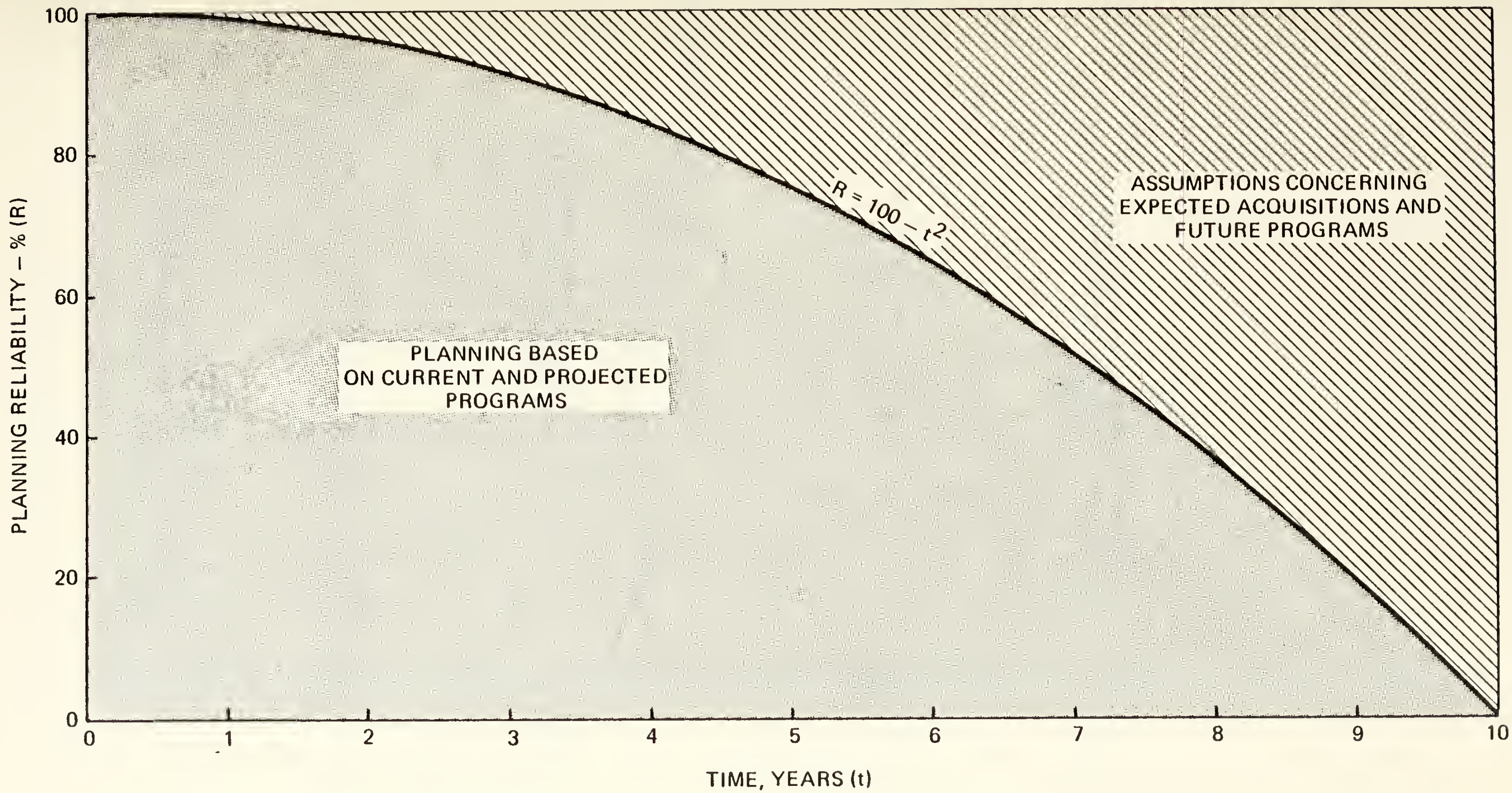

FIGURE 12
PLANNING RELIABILITY MODEL

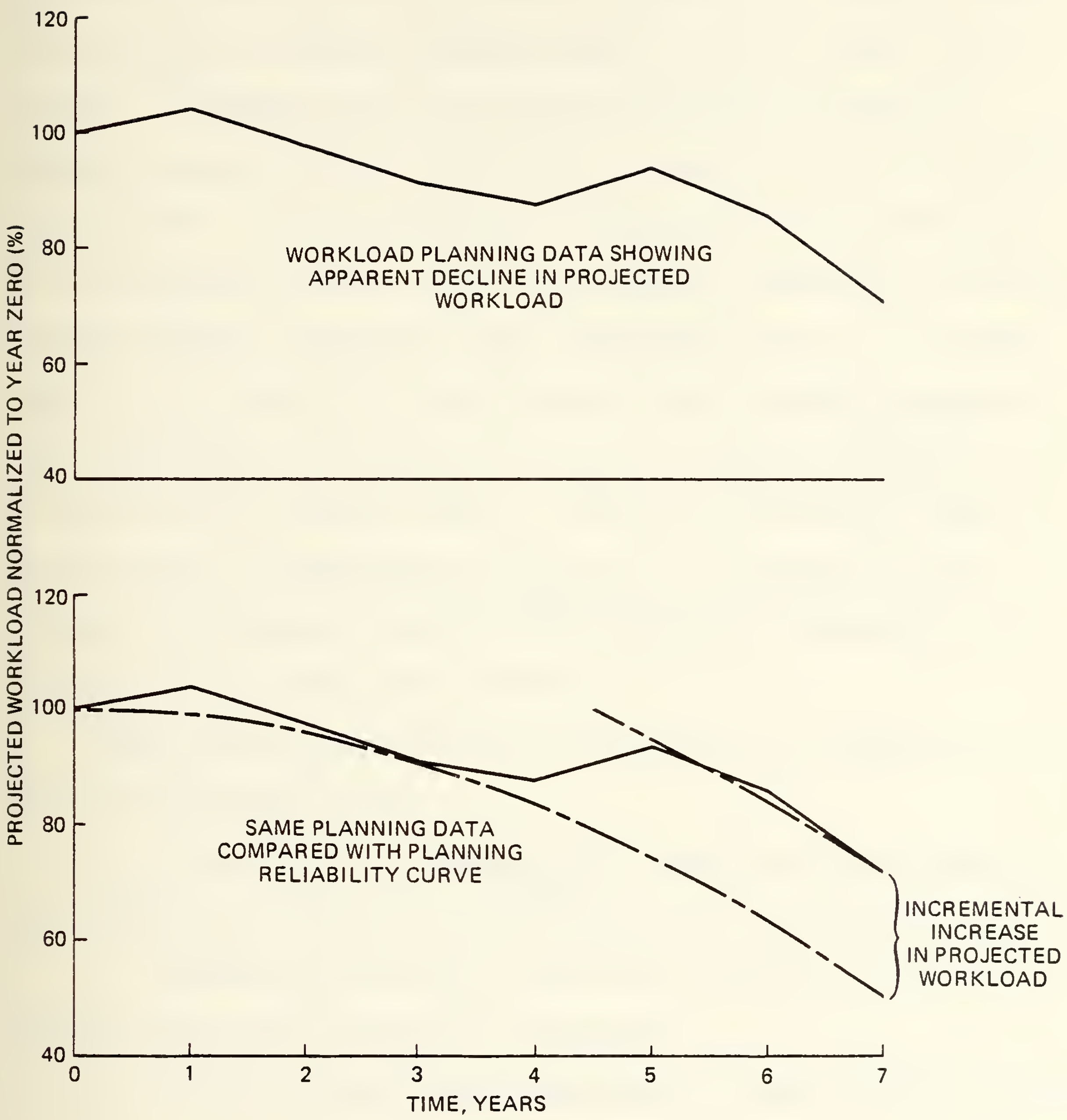

FIGURE 13
USE OF PLANNING RELIABILITY CURVE
FOR ANALYSIS OF PROJECTED WORKLOAD

C. PLANNING AND CONTROL MODEL

In order for workload planning to be meaningful, a feedback system must be devised through which controls may be provided to ensure accomplishment of the planned workload. It appears that not enough emphasis is currently placed on the feedback and control aspects at the Navy MRTFB activities. As noted earlier, integration of the Workload Plan Management System with the Standard Automated Financial System (STAFS) currently being developed for all NIF RDT&E activities [Ref. 16], would provide the necessary feedback and facilitate the required control of workload planning. A planning and control model, showing the necessary feedback loops, is presented in figure 14. As shown in the model, planning and control, when properly conducted, is a never-ending, continuous process.

The planning process may be thought of as consisting of four identifiable steps:

1. Determine, as accurately as possible, the nature of the future environment in which the plan is to be executed.

2. Establish goals and objectives for the organization within the given projected environment.

3. Establish plans and procedures to meet the established goals and objectives.

4. Implement the established plans and procedures.

In the process of forecasting the future environment, it is necessary to make assumptions concerning such items as future development test and evaluation requirements, the nature of

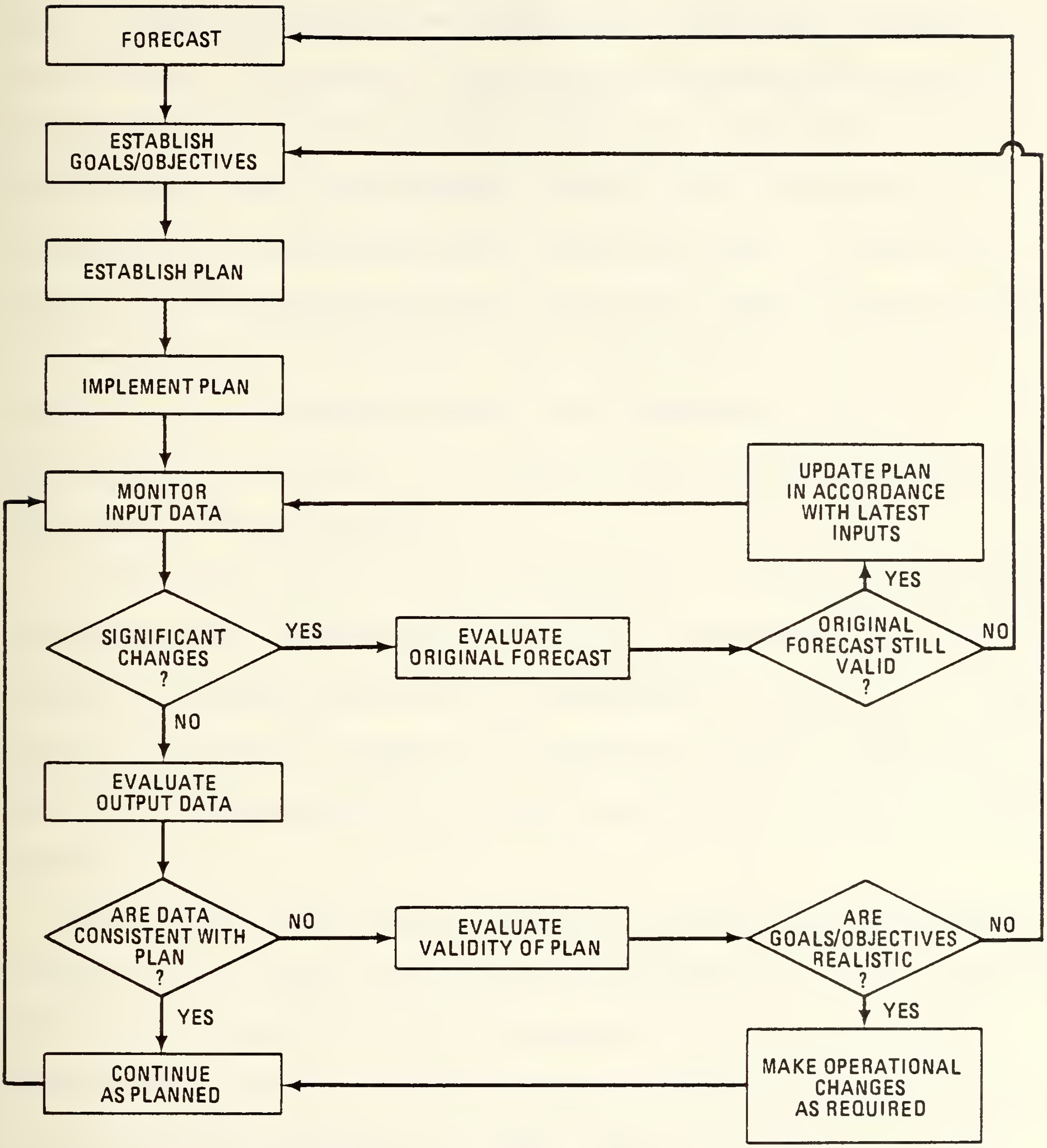

FIGURE 14
A PLANNING AND CONTROL MODEL

the technology, economic conditions, availability of resources, etc. These inputs must be documented explicitly in quantitative terms. If possible, the expected accuracy and reliability of each of the projections should be documented. These predictions form the framework within which the goals and objectives of the organization are formulated. It is now a matter of delineating specific plans and operating procedures, and establishing milestones, for achieving the goals and objectives of the organization, and exploiting, to the organization's benefit, the assets which may be available in the projected environment.

After the plan has been implemented, it must be continually re-evaluated, updated and/or revised, consistent with the latest information available to management. Implicit in the entire process is a continual monitoring of the assumptions and forecasts concerning the environment during the planning period.

As part of the planning process, controls are necessary to ensure that a viable plan has been implemented and that actions taken during operation are consistent with the plan. As a first step, the input data should be continually monitored at predetermined intervals to ensure that the information and assumptions upon which the plan is based are still valid. New information which may have an effect on the planning assumptions should be considered. Consideration of new inputs may indicate that the plan should be updated. Conversely, data may show that the assumptions upon which the plan was

based are no longer valid; in which case a complete revision of the forecast, goals and objectives, may be in order and a new plan prepared. Accurate monitoring of the inputs is essential so that the decision to update or revise the plan may be made before deficiencies show up during operation. For example, if an important resource such as a modern T&E laboratory will not be available at the assumed time, this fact should be uncovered as soon as possible so that management may take steps to expedite delivery or change T&E plans accordingly.

The ultimate purpose of a plan is to formulate a procedure by which the goals and objectives of the organization may be achieved. These goals and objectives are usually expressed as some sort of output. Therefore, it is necessary to monitor the actual output of the organization to ensure that it is consistent with the planned output. Ideally, any discrepancies should be detected early enough to make adjustments before serious consequences occur. Normally this would take place at one of the established milestones. If a discrepancy between planned and actual output becomes apparent, management should determine whether the fault lies with the operations or with the plan. Perhaps the goals and objectives set by management were unrealistic and the plan is, therefore, invalid. In this case, management must re-evaluate its goals and objectives and formulate a new plan. On the other hand, if management determines that its goals and objectives are realistic and that the plan is valid, changes must be made

in the operating procedures. For example, a re-allocation of resources may be in order.

Care must be taken to ensure that the data collected during the control phase are the same parameters as those used in the planning phase. If it is not possible to measure the same parameters, this fact must be recognized. As noted earlier, the expected accuracy and reliability of planning data should be noted. Consequently, when discrepancies show up during the control phase, management must determine whether or not the discrepancies are within the accuracy and reliability of the data before any contemplated action is taken. In other words, the discrepancy may be the fault of the measuring techniques, in which case no corrective action may be necessary (except to improve the measuring techniques, if possible).

Figure 15 presents an illustration of the use of feedback data applied to unconstrained workload planning data for the Naval Air Test Center, to indicate the need for application of controls. Planning data prepared in 1978 indicated that a surge of over 20% additional workload was to be expected during fiscal year 1978. However, at the end of the fiscal year, output data showed that the actual workload accomplished was only 4% above that for FY 1977. Planning data prepared in 1979 showed a similar surge in expected current year workload while the output data for that year showed that the workload accomplished remained essentially constant. Although 1980 workload planning data were not available at the time of

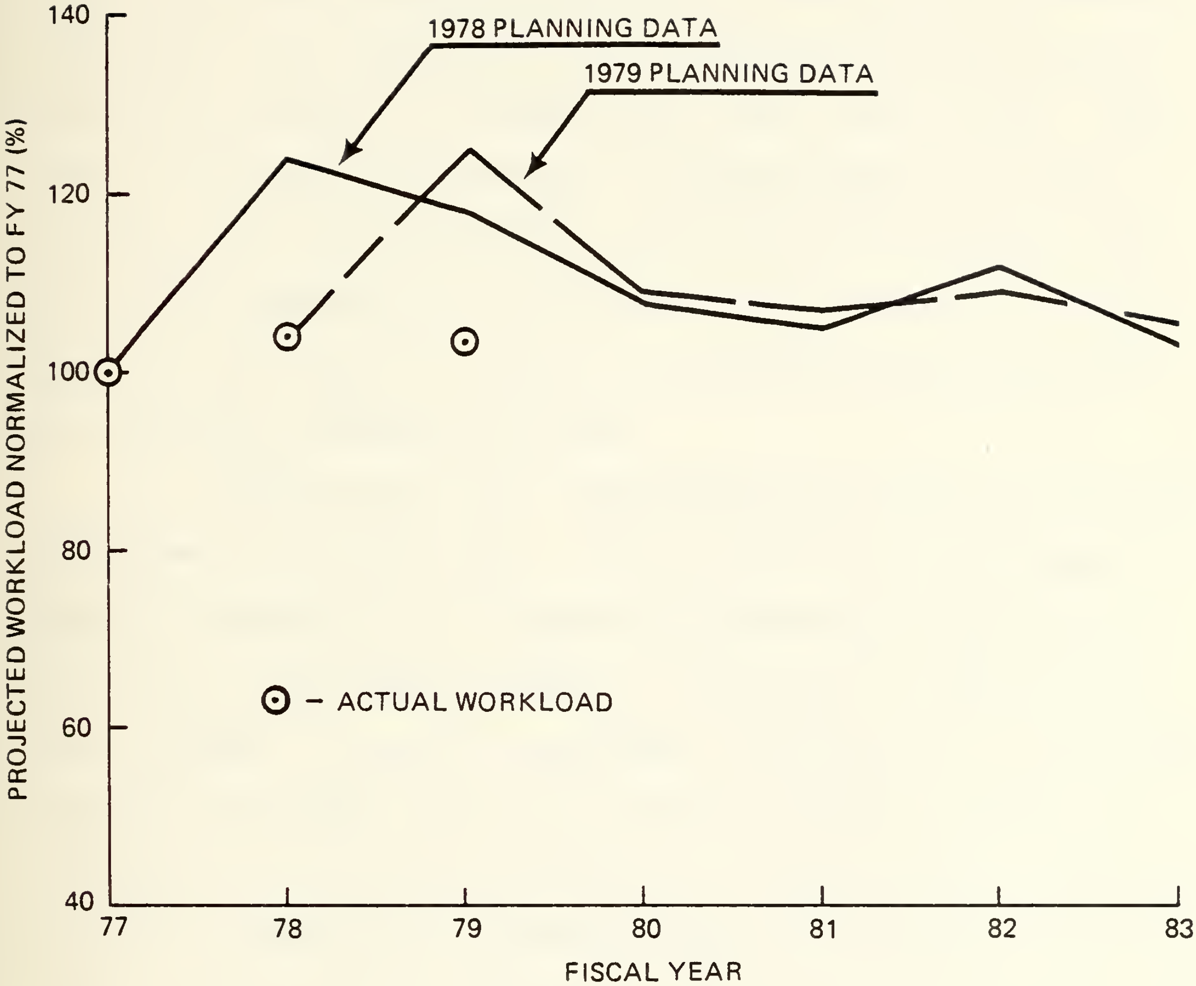

FIGURE15
PLANNING "BOW WAVE" EFFECT

this writing, it is anticipated that a similar surge in expected workload will be indicated for FY 1980.

This "bow wave" effect is characteristic of an activity in which the available resources (e.g., manpower and/or test facilities) are insufficient to accomplish the assigned workload. The planned surge in workload for FY 1978 represents the backlog of unaccomplished work from FY 1977. Then when the planned workload was not accomplished in FY 1978 because of resource shortages, the backlog was carried over to FY 1979 planning. The "bow wave" will continue through each planning year as long as the resources are inadequate to accomplish assigned workload.

It is obvious that this characteristic results in program slippages in the short run. In the long run, non-accomplishment or cancellation of important projects may result which could have a deleterious effect on important systems acquisition programs. Clearly, management intervention is indicated. The ideal solution would be to obtain adequate resources to accomplish all assigned workload in a timely manner; however, in light of externally imposed funding and manpower constraints, this solution is rarely feasible. Failing this, controls must be instituted to ensure that available resources and assigned projects are managed so that optimum utilization of the resources is accomplished consistent with timely completion of the most critical projects.

VI. CONCLUSIONS

Improved methods of workload analysis and reporting are required to enhance workload management and planning at Major Range and Test Facility Base (MRTFB) activities of the Naval Air Systems Command. The workload at a MRTFB activity is best expressed as the direct manyears of effort required to complete assigned projects funded by user/direct funds. The workload measurement techniques utilizing the Workload Plan Management System, developed by the author and currently in use at the Naval Air Test Center, are sufficiently flexible to be adaptable to all Navy MRTFB activities, and to fit changing conditions within a given activity. The system is compatible with the Standard Automated Financial System (STAFS) currently being developed for all NIF RDT&E activities.

In analyzing workload data, civil service, military and contractor manpower should each be treated as a separate and distinct workforce, each with its unique characteristics. The process of devising a viable workforce plan is an iterative one of matching the available "three-dimensional" workforce with the requirements dictated by the predicted workload. The accuracy of workload models devised for workload analysis and planning can be no better than the accuracy of the labor distribution data from which the data are computed. Consequently, it is important that accurate labor distribution data be maintained at the MRTFB activities for all three components of the total workforce, including contractor labor.

Because of the innumerable variables involved, and the unstructured nature of the work performed, it is not considered possible to express workload capacity for a MRTFB activity in explicit definitive terms. It is possible, however, to determine optimum workload for effective utilization of the workforce at a MRTFB activity.

After the manpower required to perform the projected workload has been determined, it is necessary to determine whether the physical facilities at the activity are adequate to accomplish the work. In order to adequately measure facility utilization, the unit of measure should be related to the function performed by the facility. The proposed format for reporting facility utilization and workload, based on this concept, would provide management with meaningful information pertaining to facility utilization and workload at the MRTFB activities.

Management must recognize the causal relationship between indirect costs and direct workload when the institutional budget is prepared. Furthermore, to ensure effective financial management at a MRTFB activity, this causal relationship must be taken into account in assignment of the institutional fund to the activity.

Since strategic factors affecting future workload are external to the planning organization, there are numerous uncertainties which must be taken into account when interpreting the planning data. The major uncertainties associated with workload forecasting result from the difficulty in

accounting for all of the strategic variables that may affect workload when an attempt is made to look into the future. The proposed planning reliability model, in which planning uncertainties are taken into account, may be used effectively for the analysis of planned workload.

In order for workload planning to be meaningful, a feedback system must be devised through which controls may be provided to ensure accomplishment of the planned workload. Integration of the Workload Plan Management System with the Standard Automated Financial System (STAFS) would provide the necessary feedback and facilitate the required control of workload planning.

VII. RECOMMENDATIONS

The methods, models, and techniques described in this study are recommended for adoption throughout the Navy MRTFB to enhance workload management and planning at the activity level as well as the Systems Command level. In this regard, the following specific recommendations are made:

1. The Workload Plan Management System should be incorporated by the Naval Air Systems Command as the primary workload measuring and reporting system for the Navy MRTFB. The system should be expanded to include an interactive remote mode which would allow users of the system to communicate with the system at remote terminals placed at strategic locations, including the Naval Air Systems Command. The system should be integrated with the Standard Automated Financial System (STAFS) currently under development.

2. The total workforce at a MRTFB activity should be treated as a complex "three-dimensional" workforce, the components of which are civil service, military and contractor. Each component should be treated as a separate and distinct workforce with its unique characteristics. Specific tasks may be shifted between the three workforces to compensate for manpower shortages in a particular workforce and/or achieve the most effective combination of talents for overall mission accomplishment. Consequently, accurate labor distribution data should be maintained for all three components of the total workforce, including contractor labor.

3. The techniques described in this study for the determination of optimum workload for the effective utilization of the workforce at a MRTFB activity should be adopted.

4. The workload at a MRTFB activity, or any component thereof, should be expressed explicitly in terms of direct manyears of effort required to complete assigned projects funded by user/direct funds.

5. Facility utilization should be measured in terms of relevant variables which are related to the function performed by the facility as delineated in the proposed format for reporting facility utilization and workload. The proposed form should be incorporated in the Field Activity Plan and MRTFB budget.

APPENDIX A: EXAMPLES OF OUTPUTS FROM THE WORKLOAD PLAN MANAGEMENT SYSTEM

000917

WORKLOAD PLAN

I ACTIVITY BLOCK

A. ACTIVITY NATC

B. RESPONSIBLE INDIVIDUAL C LARSEN

C. ACTIVITY IDENTIFICATION NUMBER CJ64119ATFA

D. ESTIMATED/ACTUAL START DATE 04 26 78

E. ESTIMATED COMPLETION DATE 09 30 85

II PROJECT BLOCK

A. TITLE P3C TACTICS TRAINER T&E

B. WORKLOAD ASSIGNMENT NUMBER A41341337053-2/8413000114 /A4133-03

C. APPROPRIATION APN

D. PROGRAM ELEMENT/ SUBHEAD 41AX

E. PROJECT NUMBER/DETAILED COST ACCOUNT NUMBER

III SPONSOR BLOCK

A. SPONSOR NAVAIR

B. SPONSORS PROGRAM MANAGER CODE PMA240

C. SPONSORS TECHNICAL AGENT/CODE J PONDER AIR 41306

IV MANPOWER AND COST ESTIMATES

	FY 78	FY 79	FY 80	FY 81	FY 82	FY 83	FY 84
A.DIR CIV LABOR MY/$	.5/3.4	.5/17.0	.5/11.0	.5/11.0	.5/11.0	.5/11.0	.5/11.0
B.DIR MIL LABOR MY	.5	.5	.5	.5	.5	.5	.5
C.INSTRUMENTATION							
D.MATLS/TRAVEL	/1.9	5.0/10.7	1.0/3.0	1.0/3.0	1.0/3.0	1.0/3.0	1.0/3.0
E.MAJOR PROC/CONT	/	/15.0	/30.0	/30.0	/30.0	/30.0	/30.0
F.OTHER COST							
G.TOTAL PROJ FUNDING REQUIRED	5.3	47.7	45.0	45.0	45.0	45.0	45.0

DIRECT MANPOWER REQUIREMENTS DATE 04/23/79

DIRECT MANYEARS

FISCAL YEAR	CIVILIAN A MAIN	CIVILIAN TOTAL	MILITARY A MAIN	MILITARY TOTAL	CONTRACTORS A MAIN	CONTRACTORS TOTAL	TOTAL MANYEARS
78	16.1	768.5	140.4	536.5	112.1	220.3	1525.7
79	23.0	893.0	177.8	448.9	146.0	218.5	1560.4
80	12.1	779.4	135.7	401.8	169.9	249.8	1431.0
81	15.7	765.8	222.6	428.9	185.9	272.4	1467.1
82	24.9	790.8	203.8	433.6	184.2	258.7	1473.1
83	22.9	760.3	117.0	330.1	177.6	248.1	1338.5
84	21.8	584.7	109.0	283.2	78.3	140.4	1008.3
85	4.5	251.9	58.4	161.9	1.9	56.2	510.0
TOTAL	140.9	5624.8	1214.7	3024.9	1055.9	1664.4	10314.1

WORKLOAD BY FUNCTIONAL AREA

DIRECT MANYEARS

FISCAL YEAR	VA/VF	VP/VS/ VAW	RW	SYSTEMS	MISSION RELATED TRAINING	TECH & INST SUPT	COMPUTER SUPT	MGT & ADMIN SUPT	BASE SUPPORT SERVICES	TOTAL
1978	267.4	269.7	66.7	213.6	201.2	154.0	27.2	17.7	299.7	1507.2
1979	377.5	212.9	99.7	236.5	223.0	198.7	38.7	19.2	144.1	1549.7
1980	367.1	212.0	104.0	207.7	213.0	176.6	34.6	16.1	92.2	1423.3
1981	420.9	211.6	88.5	214.1	223.0	161.4	35.1	14.7	87.9	1457.2
1982	355.3	270.7	100.0	210.8	223.0	168.4	33.4	15.8	84.2	1462.1
1983	234.9	264.5	93.3	202.1	223.0	153.3	39.1	15.7	106.8	1332.6
1984	194.6	217.1	85.1	188.4	124.0	107.7	17.2	13.6	59.9	1007.6
1985	92.5	145.0	33.7	175.6	0.0	54.4	4.3	4.3	0.2	510.0
TOTAL	2311.0	1803.5	670.0	1648.9	1430.2	1174.5	229.6	117.1	965.0	10249.7

WORKLOAD BY TEST SCENARIO IN DIRECT MANYEARS

DATE 04/23/79

	FY 78	FY 79	FY 80	FY 81	FY 82	FY 83	FY 84	FY 85
A. VEH	121.7	153.5	142.7	138.7	145.7	139.6	116.0	39.4
M. SYS	292.0	219.4	200.1	200.0	222.5	208.6	162.3	95.5
R & M	57.2	87.7	95.8	98.8	107.3	99.9	97.3	69.9
A. MAIN	268.6	346.8	367.7	424.2	412.9	317.4	209.1	64.8
VUL (EM)	21.2	17.0	17.7	14.7	14.6	12.0	9.3	6.8
E & E	39.0	38.1	38.7	39.4	38.7	40.5	35.5	31.3
GSE	46.7	53.1	54.4	65.5	69.2	79.6	82.9	80.5
ORD	57.9	75.1	43.9	48.2	42.5	33.4	31.5	51.4
CREW SYS	30.3	24.9	34.8	22.8	18.5	9.8	6.4	2.5
EW	30.1	48.3	39.1	36.5	35.7	25.0	18.1	0.5
CV SUIT	58.0	66.9	58.1	57.2	36.6	30.5	23.3	3.1
CNI	8.5	12.6	12.0	17.7	22.0	22.1	18.1	1.1
A/B INST	59.3	63.7	45.5	43.9	53.1	49.6	39.1	22.5
RANGE	28.2	50.0	44.9	47.0	44.1	33.8	18.6	5.1
TELEM	15.2	28.5	32.7	24.7	24.0	22.2	12.3	3.7
COMPUTER	27.2	38.7	34.6	35.1	33.4	39.1	17.2	4.3
INST LAB SERV	51.3	56.5	53.5	45.8	47.2	47.7	37.7	23.1
TID	17.1	18.6	15.5	14.1	15.2	15.1	13.0	3.7
BASE SUP	295.7	150.7	98.9	93.4	89.4	112.1	60.6	0.8

WORKLOAD PLANNING DATA FOR STRIKE
FUNCTION = M. SYS   BRANCH = CIVILIAN
(DATA AS OF 04/30/79)

PRIME COST CENTER = SA

NFC ID	SUB CC	SHORT TITLE	PROJ OFF/ENGR	PSD	PCD	FY78	FY79	FY80	FY81	FY82	FY83	FY84	FY85
1177	SAHO	F-18 WEAPON SYSTEM T&E	J GREGSON	79000	83222		1.2	.8	.2	.5			
989	SAHO	F18 NPE TIR	R J BULL	79080	80020		.3	2.0					
993	SAHO	F18 BIS	R J BULL	79273	81273			1.3	4.0				
991	SAHO	F18 NPE TV	R J BULL	80050	81273			1.1	2.4				
994	SAHO	A18 BIS	R J BULL	81120	82090				2.1	2.0			
1160	SAHO	AV8A DIGITAL IWAC	DAVE STEFANIC	79200	80270		.5	1.2					
1161	SAHO	AV-8A HMD RRM	J D STEFANIC	79000	80180		.4	.4					
1159	SAHO	AV-8B MISSION SYSTEMS	J D STEFANIC	79000	85365		1.6	4.5	3.8	3.8	4.0	2.0	.9
1167	SAHO	F18 RADAR	E TEHANSKY	78001	83255	1.5	2.4	2.9	4.7	3.6	2.0		
1168	SAHO	F18 INS	J BROWE	78001	83255	1.0	1.0	1.5	1.5	.4	.6		
272	SAHO	IA7C MIS TRIALS	LT R BATDORF	78070	78365	2.0	1.3						
587	SAHO	FLIR TECHEVAL FOR ATE	D T DICKEY	78074	79270	1.1	.2						
247	SAHO	RING LASER GYRO	BROWNE	77001	80100	.4	.8						
239	SAHO	ASN92 AT SEA VERIFICATION	LT D ANDERSON	76180	78180	.5							
868	SAHO	EC153FMERSONEC153RADAR	PITCHER	77334	80273	.4	.4						
860	SAHO	F18 MSTL	SMULLEN	78001	85273	7.4	5.5	2.0	2.0	1.0	1.0		
907	SAHO	FLIR CTE FOR ATE	D T DICKEY	78074	78115	.4							
908	SAHO	EMP A6	LT G BROWN	78050	78170	.1							
897	SAHO	ATAGA SYSTEM	J MARSHALL	78025	81273	.4	.3						
909	SAHO	A-7 FRENCH GYRO	T QUINN	78001	79273	.4							
1270	SAHO	A18 NPE	R J BULL	81031	81270				1.4				
597	SAHO	A6 IMPROVEMENTS	STEFANIC	79100	84274			.2	.9	1.5	2.0	2.0	
595	SAHO	A4 IMPROVEMENTS	PITCHER	81100	83100				.2	.4	.2		
714	SAHO	AGE AMTI	CLELAND/SMITH	78031	78270	1.0							

DIRECT FUNDING BY PRIME COST CENTER — DATE 04/23/79

($ 000)

FISCAL YEAR	SA	AT	RW	SY	TP	TS	CS	TC	CT	CR	BASE SUPT
78	14251.4	11558.2	2414.2	8224.7	4195.4	2475.2	74.0	187.3	42.9	15.6	5649.7
79	17820.1	9772.7	4482.6	8188.5	5975.0	4990.3	335.9	198.5	45.3	16.7	5985.2
80	21675.2	9229.9	5574.0	6516.5	7202.0	5942.9	324.0	200.3	45.3	18.5	6339.9
81	25040.1	11775.6	5350.3	6413.9	8220.0	4700.1	173.8	215.2	45.3	20.0	6815.6
82	19764.2	14596.8	6050.9	7131.9	8957.0	4272.5	46.8	231.6	45.3	21.4	7274.0
83	16265.1	13662.5	4364.1	6659.5	9787.9	4381.0	0.0	250.3	45.3	23.2	7787.0
84	11221.4	9270.0	4671.4	6195.1	10685.0	8439.4	0.0	269.9	45.3	25.1	8033.8
85	5375.3	8166.7	2578.7	5466.7	0.0	1918.7	0.0	0.0	45.3	0.0	1770.6

FINANCIAL DETAILS

DATE: 04/23/79
PAGE 19

USER/DIRECT FUNDS DETAIL
($ 000)

APPN / SPONSOR	PE/SH / PROJ/CAN	SHORT TITLE / AIRTASK	JO / WU	RECORD IC	FY78	FY79	FY80	FY81	FY82	FY83	FY84	FY85
RDTEN	64263N	F-18 INSTR SUPPORT	J607389SA	1	543	1474	2298	961	411	494	533	
NAVAIR	W0625	A51C-5102/001-D/TWTW04CCCO	A5102F-11									
RDTEN	64263N	F18CM A/C ARM SYS COMPT	J6C3487SY	57	17	117	160	198	273			
NAVAIR	W0625	A51C-5102/053-D/7W0625CCCO	A5321M-02									
		PASS TO OTHERS NSWC	12									
		SUM PASS TO OTHERS										
RDTEN	64263N	F18SM F19 SMS TECH SUPP	J607378SY	79	14	11	28	24	21			
NAVAIR	W0625	A51C-5102/053-C/7W0625CCCC	A52211B 08									
RDTEN	64263N	F-18 WIRING EQUIP MONITOR	AU11710SY	134		18	22	18	19			
NAVAIR	W0625	A51C-5102/053-D/8W0625CCCO	A533C1-28									
RDTEN	64263N	F-18 REL AND MAIN SUPPORT	BT36905SA	185	461	347	459	531	600	567	619	685
NAVAIR	W0625	A51C-5102/053-D/9W0625CCCC	A52C54-35									
RDTEN	64263N	F404-GE-400 ENGINE	AR5637[illegible]5SA	249	92	146	42	978	854	812	812	815
NAVAIR	W0625	A5365361/053-D/7W0625CCCCC	1R42P9A									
RDTEN	64263N	F18 IECMS	ET31700SA	250	6	14	24	17	15	13	14	17
NAVAIR	W0625	A51C-5102-053-D/9W0625CCOA	53644-23A									
RDTEN	64263N	F18 FUEL SYSTEMS	BT31705SA	251	8	15	17	12	12	11	12	12
NAVAIR	W0625	A510-5102-053-C/9W0625CCCC	A53632E-29A									
RDTEN	64263N	F18 AUX/SECDRY PWR SYS	AU11709SA	252	3	8	18	15	16	12	13	13
NAVAIR	W0625	A51C-5102-053-D/9W0625CCCO	A53641A-33A									
RDTEN	64263N	F-18 EW EVAL		254			45	327	400	558		
NAVAIR	W0625											
		PASS TO OTHERS NWC	7					50				
		SUM PASS TO OTHERS						50				
RDTEN	64263N	F-18 CV SUITABILITY	AP41685SA	286	34	274	337	704	406	183		
NAVAIR	W0625	A51C-5102/053-D/7W0625-COC	A53713-03									
		PASS TO OTHERS NESTE	4			25	50	50	65			
		SUM PASS TO OTHERS				25	50	50	65			
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		PASS TO OTHERS NSWC	09				3	17	15			
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REFERENCES

1. Office of Management and Budget Circular A-109, Major System Acquisition, 5 April 1976.

2. Department of Defense Directive 5000.1, Major System Acquisition, 18 January 1977.

3. Department of Defense Directive 5000.2, Major System Acquisition Process, 18 January 1977.

4. Department of Defense Directive 5000.3, Test and Evaluation, 11 April 1978.

5. OPNAV Instruction 5000.42A, Weapon Systems Selection and Planning, 3 March 1976.

6. OPNAV Instruction 3960.10, Test and Evaluation, 22 October 1975.

7. Department of Defense Directive 3200.11, Use, Management and Operation of Department of Defense Ranges and Test Facilities, 18 June 1974.

8. NAVMAT Instruction 5450.31, Consolidation of Navy Ranges, Test Activities, and Targets Test Resources, 29 March 1976.

9. NAVMAT Instruction 3960.10, Policy and Procedures for Workload Management at the Navy Major Range and Test Facility Base (MRTFB) Activities, 3 February 1978.

10. NAVAIR Instruction 3900.8A, Airtask and Work Unit Assignments to Field Activities, 22 March 1977.

11. Nadler, Gerald, Work Design, Homewood, Illinois: Richard D. Irwin, Inc., 1963.

12. Cooper, W. W., Niehaus, R. J., and Nitterhouse, D., Workforce Goals Planning for the Naval Laboratory System, Research Report No. 31, Washington, D.C.: U. S. Navy Office of Civilian Personnel, 1977.

13. Martin, A. J., and Hughes, Harriet S., "Integrating Workload Planning with Budgeting and Accounting," Armed Forces Comptroller, Vol. 23, No. 4 (November 1978).

14. Bonbright, Bruce D., Methodology for Uniform Measurement of Capability, Capacity, and Workload within the Major Range and Test Facility Base. A Report of the NAVWPNCEN Task Team, China Lake, California: Naval Weapons Center, 1977.

15. Chase, Richard B. and Aquilano, Nicholas J., Production and Operations Management: A Life Cycle Approach, Revised Edition, Homewood, Illinois: Richard D. Irwin, Inc.. 1977.

16. Navy Industrial Fund Research, Development, Test and Evaluation Standard Automated Financial System, STAFS, Final Draft Functional Description, 1 October 1979.

17. Bonham, T. W., Clayton, E. R., and Moore, L. J., "A Gert Model to Meet Future Organizational Manpower Needs," Personnel Journal, Vol. 54, No. 7 (July 1975), pp. 402-406.

18. Buffum, Robert Stratton, Workforce Planning Models for the Naval Air Test Center, Master's Thesis, Monterey, California: Naval Postgraduate School, 1978.

19. Mavrikas, Christos, Efthimios, Optimal Five-Year Planning Using Mixed Integer Linear Programming Three Models Implemented for Naval Air Test Center, Master's Thesis, Monterey, California: Naval Postgraduate School, 197.

20. Douglas, Evan J., Managerial Economics: Theory, Practice, and Problems, Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1979.

21. Steiner, George A., Top Management Planning, Toronto, Ontario: Collier-Macmillan Canada, Ltd., 1969.

22. Ackoff, Russell L., A Concept of Corporate Planning, New York: Wiley-Interscience, 1970.

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